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Reclamation of High-Speed Steel

by Chester L. Lucas[1]

The high cost of metals and the need of rigid economy in their use, which must be enforced in order to meet war needs, gives this article on reclaiming high-speed steel scrap unusual interest and value in the present crisis. The scarcity of tungsten has forced the price of high-speed steel to an unprecedented height, and it is imperative that all tungsten be conserved wherever possible. The article describes the practice of utilizing worn-out high-speed tools and converting them into new high-speed steel.

FOR years, the mechanical world has paid a great deal of attention to saving the scrap, chips and sweepings of gold, silver, aluminum, copper, brass, lead and other metals of comparatively high value. Practically no effort has been made, however, to reclaim the scrap from high-speed steel, although it has greater value than any of the other metals except gold and silver. It is true that high-speed steel tool shanks are forged down for tool bits in some factories, but in most cases the scrap is sold for any price that it will bring.

High-speed steel scrap has always been of more or less doubtful quality, and naturally most steel manufacturers do not care to take in the scrap of other brands of steel than their own; consequently the market price for scrap has been low in comparison with the price of the original steel. That this does not bear the same relation to its original cost as does the scrap of other metals may be seen in the accompanying table. While the scrap of non-ferrous metals brings from 30 to 60 per cent of the cost of the original metal, steel scrap—notably that from high-speed steel—brings but a fraction of the original cost.

This discrepancy is probably largely due to the trouble experienced in separating steel scrap, because of the similarity of color and general appearance of all steels, especially after machining. An ordinary laborer can easily separate non-ferrous metal scrap because of its distinguishing colors, but it is a difficult matter to separate high-speed steel scrap from tool steel scrap. For this reason, therefore, high-speed steel scrap has been neglected. Steel manufacturers have sometimes taken back high-speed steel scrap from good customers in order to protect the accounts, but, in general, the practice has been to take back scrap only when necessary, and then to work it off in new steel as "diplomatically" as possible. With high-speed steel selling at $2.50 per pound and up, it would seem to be worth while to reclaim the scrap on a scientific basis, and with this in mind the Onondaga Steel Co., Inc., of Syracuse, N. Y., was formed for the purpose of reclaiming high-speed steel. By the process and working methods about to be described in this article, high-speed steel scrap at once takes on a value more nearly proportionate to the original cost as compared with other metals.

[1]Associate Editor of MACHINERY.

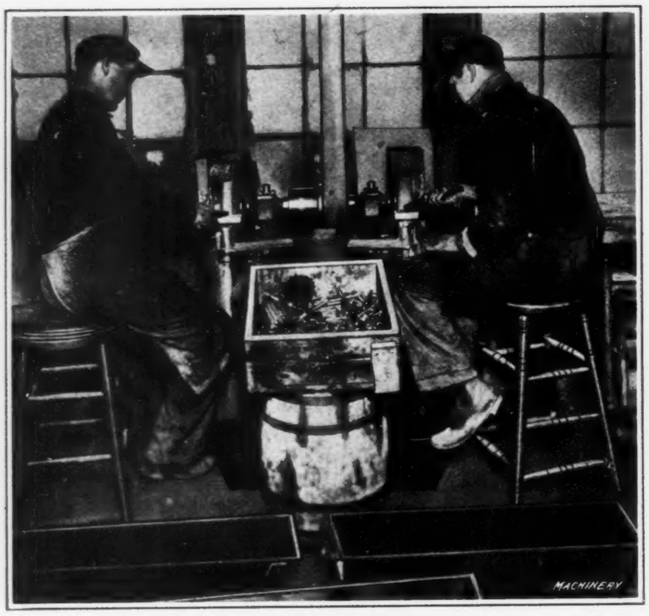

Fig. 1. Sorting High-speed Steel Scrap

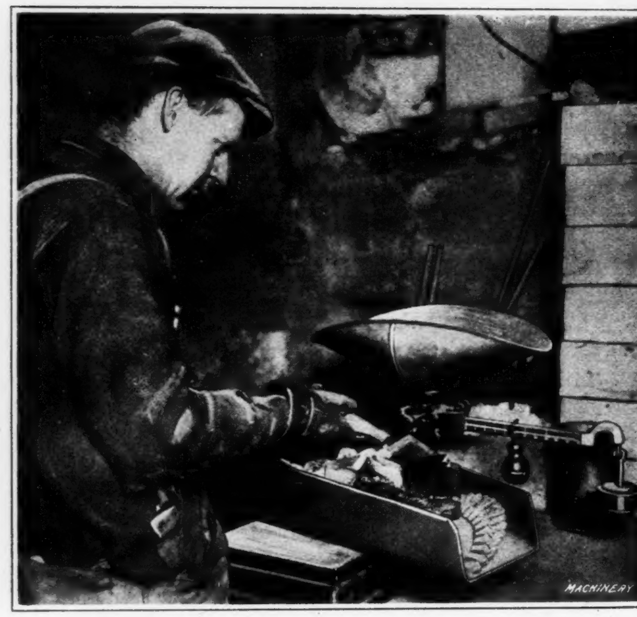

Fig. 2. Weighing out Crucible Charge

High-speed Steel Scrap

A view of a typical high-speed steel scrap shipment, as received for reclamation by this company, is shown in the leading illustration. As may be seen, this scrap is a typical shop collection of broken cutters, drills, reamers, tools and end trimmings from the forge shop. The pieces comprise a number of different brands, and undoubtedly ordinary tool steel scrap has become mixed with it to some extent. The problem is to sort this steel into the various grades or qualities, and by properly proportioning each quality, obtain a uniform mixture of scrap to which is added certain carefully determined quantities of new materials, bringing the whole up to the required standard through remelting; then by a selected series of heat-treatments and hammer operations it is worked into a steel of equal or better quality than the original material.

COMPARATIVE PRICES OF NEW METAL AND SCRAP METAL IN FEBRUARY, 1917

Metal	New, per Pound	Scrap, per Pound	Metal	New, per Pound	Scrap, per Pound
Aluminum..	$0.59	$0.21	Zinc	$0.11	$0.085
Tin	0.51	0.38	Lead	0.09	0.07
Nickel	0.45	0.30	H.S. Steel..	2.50	0.10–0.25
Copper	0.32	0.24	Tool Steel..	0.16	0.04
Brass	0.54	0.20	Mch. Steel..	0.07	0.01

Machinery

Sorting the Scrap

The sorting of the high-speed steel scrap into different grades is the first and one of the most important steps in the process of reclamation. Fig. 1 shows two steel sorters at work. Several methods are used to determine the grade. First, and most important, is the "sparking" method. The sorters take each piece of stock and test it for qualities of sparks made in contact with a grinding wheel. From long experience, they are able to tell by the color of the spark, the size and shape approximately to what class the particular piece of steel belongs. The average machinist knows the difference between the sparks from high-speed steel and tool steel or machine steel, but the Onondaga steel sorters have carried this method much further and are able to tell the quality of high-speed steel by the sparks. A series of test-bars are at hand, each one of which is marked with its chemical content, so that in cases of doubt the sparks may be compared with those from a piece of known content. Each piece in every steel shipment goes through this sparking test, and is thrown into the box containing steel of like quality. To assist in this classification, the sorters become acquainted with the average grades of high-speed steels that are used in making drills, reamers, taps, cutters, etc., and this knowledge helps to verify their judgment in sorting the scrap.

Charging the Crucibles

After the steel of a shipment has been properly sorted it is ready to be charged into crucibles for melting. The steel contents for each crucible are carefully weighed, as is shown in Fig. 2, before being placed in the crucible. Irrespective of the quality of the high-speed steel scrap received, it is the aim of the Onondaga Steel Co., Inc., to turn out high-speed steel of uniform quality; that is, with as nearly as possible the same tungsten content. Fig. 3 shows how the tungsten is

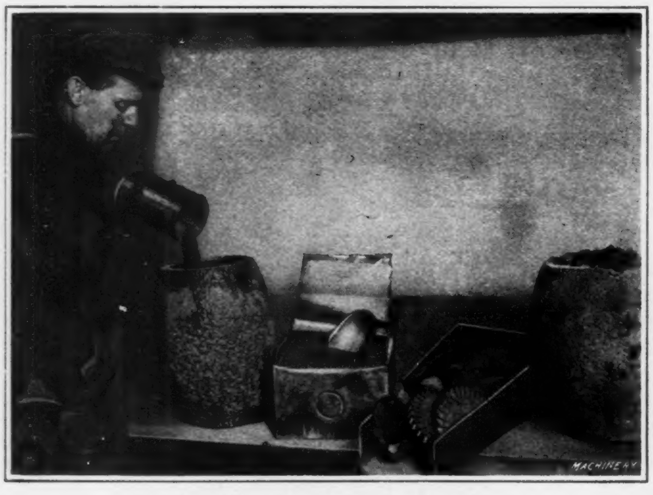

Fig. 3. Adding Tungsten to Crucible Charge

Fig. 4. Hardening Tool Bits

Fig. 5. Stripping Ingot Molds

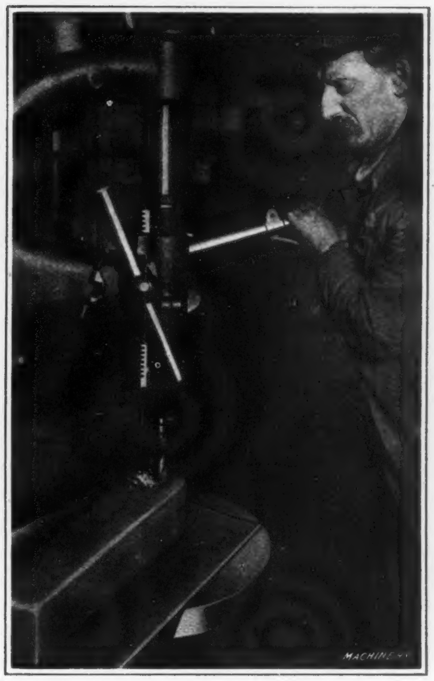

Fig. 6. Drilling Ingot to secure Chips for Analysis

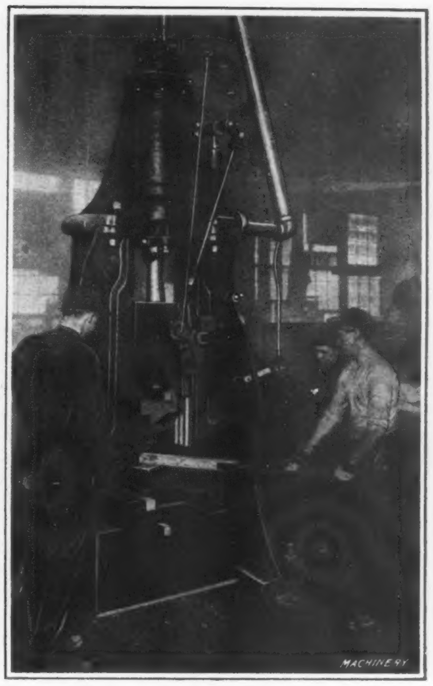

Fig. 7. Rough-cogging Ingots

added to the charge in the crucible. Incidentally, the box of tungsten in the foreground of this illustration represents $600.

Melting and Teeming

The crucibles, properly charged, are lowered into the gas furnaces, and after being heated for four or five hours, the steel is entirely melted, absorbing the tungsten that has been added, and is ready for "teeming" or pouring into the ingot molds. The ingot molds accommodate an ingot about four inches square, and twenty-three inches long. The teeming is shown being done in Fig. 10, and the operation in this plant does not differ materially from the customary steel-making practice.

Fig. 5 shows the way the ingot molds are stripped and the ingots removed. The molds are of the split type and the halves are held together by square rings that are driven tight with tapered wedges. The high-speed steel scrap is now in the form of an ingot containing the proper amount of tungsten and other elements and is ready for hammering down to the finished sizes. As soon as the ingots have been stripped from the molds, they go to the annealing furnaces, where they undergo a heat-treating process before being "cogged" or rough-hammered.

After being thoroughly cooled, the ingots are taken to the grinding department, where they are gone over very carefully, as shown in Fig. 11, to remove any imperfections or blemishes in the faces of the ingots before being forged down to size. It is obvious that should any of these surface defects remain in the ingots, they would be hammered down with the surface and would result in flaws in the finished product.

"Cogging" the Ingot

The ingots are now heated to a full forging heat, and are "cogged" to bars two inches square by five or six feet long. The ordinary type of steam hammer is used, as is illustrated in Fig. 7, and the ingots are rapidly reduced. At this point in the reduction process, the semi-finished bars are again taken to the grinding department to have any imperfections removed and the corners of the bars ground off. This operation is illustrated in Fig. 8.

The two-inch bars are now taken to smaller hammers, where they are "cogged" to the smaller sizes; they then go to finishing hammers, where they are drawn down to the final sizes, as required by the customer. Care has to be used at this stage of reduction, as high-speed steel in the smaller sizes requires most careful treatment in heating and forging.

Inspection

Inspection forms an important part in this reclamation process. In addition to the great care that is used in sorting

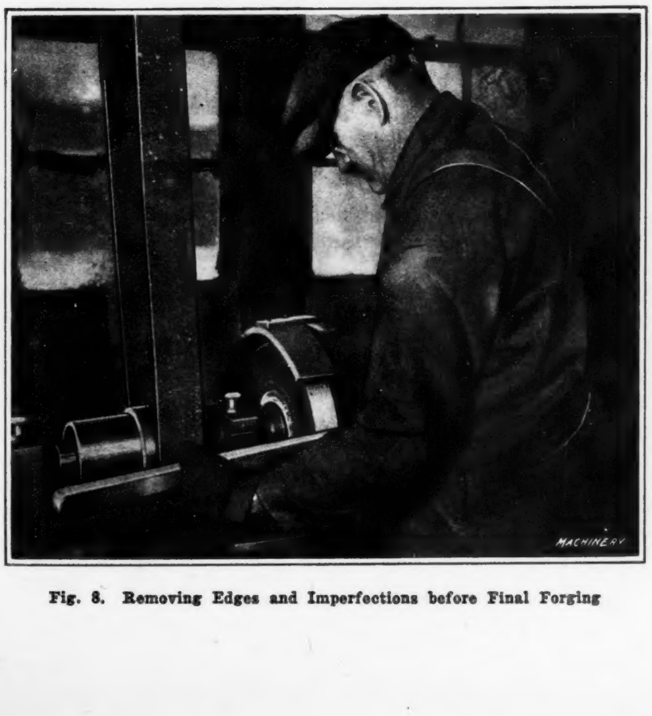

Fig. 8. Removing Edges and Imperfections before Final Forging

Fig. 9. Cropping Bar Ends and inspecting

Fig. 10. "Teeming" or pouring Steel from Crucibles

the scrap steel, in charging the crucibles with the right "mix," etc., each of the ingots is tested for chemical content before reduction. Fig. 6 shows how the ingot is drilled, and the drill chips go to the chemical laboratory for analysis. From a report of the head chemist, it is of interest to note that in a comparison of thirty different ingot tests, all came within a surprisingly narrow range around the standard of tungsten and carbon aimed at. After the bars have been reduced to their final dimensions, the ends of each bar are cropped or broken off, as shown in Fig. 9, the resulting fracture is carefully examined, and the surface of the bars is inspected closely for seams. Defective bars are thus quickly detected and thrown out, while the good ones go to the finishing room, where they are labeled and packed for shipment.

An important use to which reclaimed steel is put is in the manufacture of the tool bits which the company markets. Fig. 4 shows the final, and a most important, step in the manufacture of tool bits. This is the hardening operation, and at this plant the tool bits are hardened singly. The illustration shows how the hardener feeds the tool bits into the furnace and withdraws them one at a time with special tongs. These tongs, incidentally, are worthy of notice because, by means of a telescoping finger, they can be operated with one hand. By putting the tool bits through the hardening operation singly instead of in lots, each tool receives the proper heat and no sacrifice in quality for the sake of quantity is made.

Very little has been done, up to the present, in reclaiming high-speed steel scrap, considering the fact that hundreds of tons of high-speed steel are manufactured every year. For this reason, the reclamation process should prove of great value to the mechanical world.

Fig. 11. Grinding Ingot before rough-forging

THE MACHINIST IN RELATION TO MODERN MANUFACTURING

BY H. W. JOHNSON [1]

There seems to be considerable apprehension regarding the ultimate result of the thinning out of the ranks of all-around machinists. It is true that in the average modern shop doing mass production the all-around machinist does not appear in any considerable numbers, but the writer does not believe that this condition is wholly bad. The old order, in which general machinists manned practically all the machines in a shop, was only one stage in the development of machine-shop management. Jobs were quite likely to be given to individual workmen to be completed in all operations. This scheme worked well at the time and is still likely to be used on repair work, although much of this can also be profitably subdivided.

When parts came to be made in such large lots that machines ran for days on one operation, the all-around man was the first one to become tired of running the same thing day in and day out. Handy-men were found to be better adapted to this sort of thing, and as they had no experience in governing speeds and feeds, scientific adjustment of output was easy. The proposition is sound from every viewpoint. The firm gets a big output, the man gets far more money than he earned as a laborer, and the machinist gets a raise and becomes a gang boss. When functional foremanship is in use, men with some, but not all, of the qualifications of successful military foremen are capable of giving satisfactory service. In other words, not only has machine operation been simplified, but also supervision.

It has been pointed out by some that the average man in the building trades approaches more nearly to all-around proficiency than does his brother in the machine shop. This is so, but it does not necessarily mean that a desirable state of affairs exists in the building trades. It simply indicates that the building trades are just about where the machine business was before the Taylor system was evolved. Some progress has been made in bricklaying, but it has not reached every mason contractor. It is only reasonable to look for as large a saving through scientific building as has been made in scientific manufacturing. Meanwhile the consumer (property owner) pays the bill. Neither do we believe that the larger unit pay in the building trades is attracting young men who might have become machinist apprentices. In the past six years the writer has employed in machine-shop work men from practically all the building trades. They were in the machine shop because they could average more per month than at their trade, this being due to absence of interference from bad weather and to the ability of the shop to make stock in advance of orders, which is seldom possible in house building. The machine shop provided steady work.

It is better not to try to sweep back the tide with a broom. Specialized manufacturing is here to stay because it is giving us better manufactured goods for less money than the old scheme could. With this system have come the specialist operator and the functional foreman. Just now we are using all-around machinists for gang bosses because they are available, but it will not be necessary to continue this practice, for gang bosses as well as machine operators can be trained to proficiency in their particular lines. Some positions will call for technical graduates. Maintenance work and some jobbing and toolmaking will call for all-around men, and it is fortunate that maintenance and tool departments and jobbing shops are the very places in which general machinists can be made. The supply can be fitted to the needs.

However, the writer does not belittle the importance of the various apprentice schemes now being advanced, for it is a peculiarity of the machinist's trade that it fits him for more positions, both in and out of the business, than any other line except politics. Nor is the money spent on a boy necessarily lost if he later takes up some other line of work. He is quite likely to send business to the old shop, if his memories of that shop are of fair treatment in a plant making a meritorious article.

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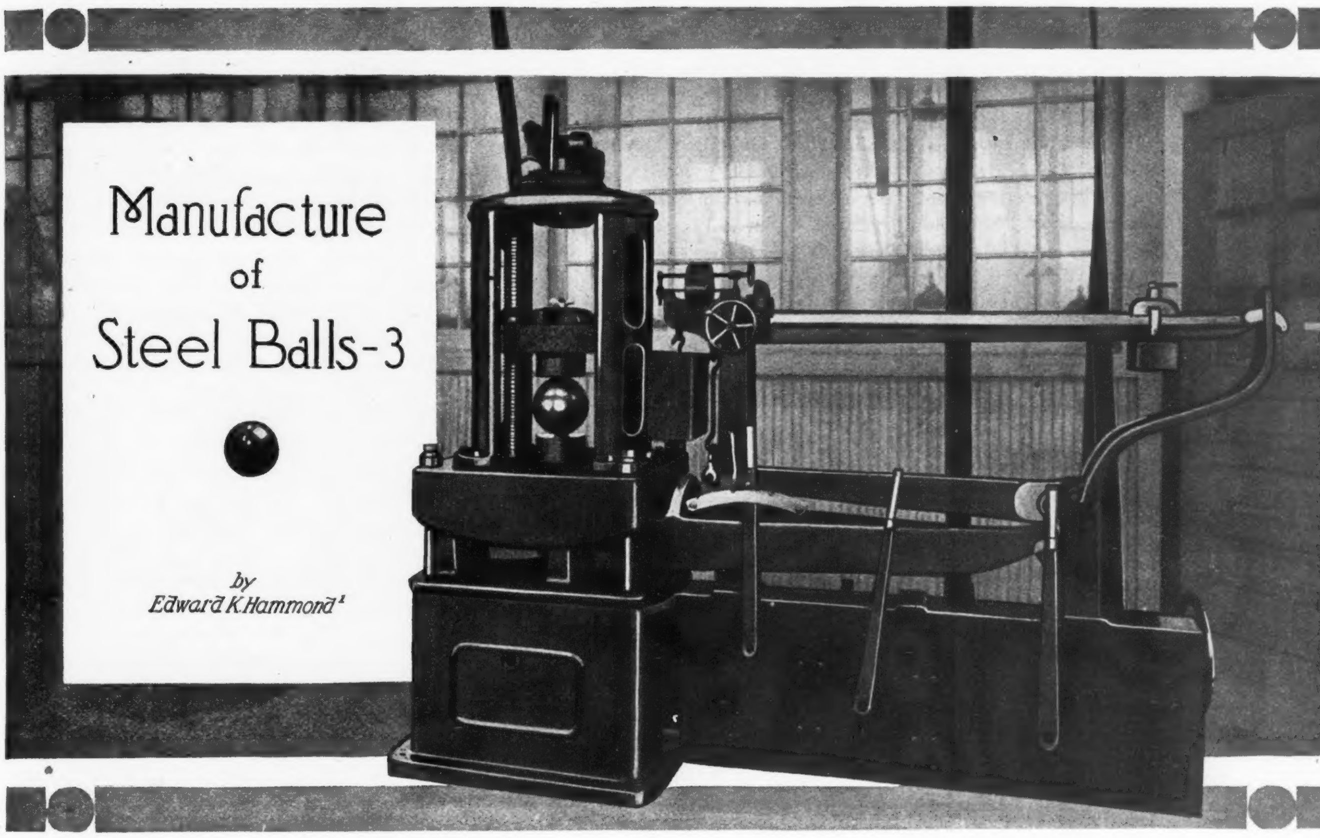
Manufacture of Steel Balls-3

by
Edward K. Hammond[1]



A DESCRIPTION of the work of the inspection department which was published at the end of the preceding installment of this article explains the great care which is taken in examining the finished product of the Hoover Steel Ball Co. in order to be sure of eliminating all balls that are in any way defective. It is obvious that in the tonnage manufacture of a product that must meet such exact requirements as balls for use in high-grade annular bearings, the greatest care must be taken in the selection of raw material and in conducting each step in the process of manufacture in order to produce balls that will pass the inspection department. In addition to the requirements of high-grade balls that were referred to in the description of various examinations that are conducted by the inspectors, it is absolutely necessary for the balls to be of uniform hardness right to the center, because this is the only way of being sure that all balls will possess uniform durability and elasticity.

Assurance must be obtained that the steel received at the factory is of a suitable grade to produce balls that will fulfill the specifications before manufacturing operations are started, because if the balls were finished before it was found that they were defective, the raw material and the labor involved in converting this material into finished balls would be lost. Data showing that the steel fulfills these specifications are obtained from the results of tests conducted in the laboratory which is equipped with all the necessary apparatus for making physical and chemical tests upon the raw material. In addition, the laboratory is referred to by heads of the various manufacturing departments when any case of trouble arises, such as failure of the balls to harden properly, the production of more than the usual number of balls with cracks, and other troubles of this kind. Some exceptionally interesting results have been brought to light as the result of work conducted in the laboratory, and the present installment of the article will deal with the methods used by the metallurgists of the Hoover Steel Ball Co. in conducting tests on the raw material and the finished product; and reference will be made to some of the information that has been brought to light as a result of these tests.

Testing Raw Material

There are sidings from the Ann Arbor Railroad entering the plant so that cars may be run directly to the building in which the raw material is received and to the building where the finished balls are packed for shipment. The method of procedure in testing raw material is the same for both straight bars and stock which comes in coils; it consists of selecting six bars or coils of every size of stock received at the plant, from the end of each of which is cut a sample eighteen inches in length. From the inner end of this sample is cut a piece two inches long, which is boiled in 20 per cent hydrochloric acid for fifteen minutes to remove the outer scale. After this has been done, the surface of the metal is carefully examined to see that it is free from cracks or seams. In addition to removing the outer scale, the acid tends to accentuate any surface defects that may be present, so that those that might be invisible in the bar as it comes to the plant can be quite easily seen after the treatment. In ball manufacture it is highly important for the stock to have a smooth surface, because any slight defects are carried right through the process of manufacture and are likely to become accentuated, with the result that balls produced from this stock will be rejected by the inspectors.

The regular routine tests of the raw material inspected in the laboratory also include a chemical analysis of the steel—especially as regards its carbon and chromium content—and a Brinell hardness test. The latter is especially important in the case of "wire" under 11/16 inch in diameter that is converted into ball blanks by the cold-heading process, because excessive hardness of this material is likely to give trouble through the breakage of the cut-off knives or the dies used on the cold-headers. In order to give the best possible results, stock for the cold-heading machine should have a Brinell hardness of 170, but material of slightly greater hardness could be worked without undue trouble. When the preliminary tests made in the laboratory show that the steel is not up to standard, further examinations are made to determine possible defects produced by the mechanical treatment at the rolling mills. This is done by polishing one end of the test sample and examining the surface under a microscope to determine defective conditions resulting from segregation or the formation of a pipe at the center of the bar. In cases where laboratory tests do not show that the stock is defective, an "unloading ticket" is made out and sent to the stock-room, authorizing the material to be taken from the cars and placed in storage, ready to be drawn out on requisition by the manufacturing department.

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Tests of Seamy Cold-drawn Wire

In describing the inspecting of balls, reference was made to the rejection of those with what are known as fire cracks. These exist almost entirely in balls up to and including ⅝ inch in diameter, the blanks for which are made by the cold-heading process; it seldom happens that fire-cracked balls are found in sizes over ⅝ inch, blanks for which are made by the process of hot-forging. A study of this subject reveals the fact that after cold-heading, ball blanks almost invariably have some sort of crack, and in a great many cases these cracks are quite deep. At first it was thought that this was due to a large percentage of chromium in the steel, which has a tendency to make the metal brittle, but subsequent investigation showed that this is not the case.

Study of Seams in Steel Bars and Wire

Defects revealed by boiling the metal in hydrochloric acid run lengthwise of the bar; sometimes these extend for the entire length of the coil, while in other cases only one end is found to be defective. For want of a better name, the laboratory has called these defects "seams," and it has been proved that wire with seams will in all cases be split to some extent during the process of cold-heading, while that without seams will produce perfect balls in the cold-heading machines. In some cases the cracks opened up in the balls while cold-heading are not so deep that they cannot be eliminated during the subsequent treatment to which the blanks are subjected; but in other cases it may happen that these splits in the blanks are so deep that they reach below the surface of the finished balls, in which case the balls will be rejected by the inspectors because they contain what are commonly known as "fire cracks."

The investigations conducted in the laboratory relative to troubles resulting from stock having seams or scratches have developed the following information: (1) Cold-drawn wire on which the surface is apparently quite smooth, and on which no seams are visible, is found to possess minute laps or seams after being etched with hydrochloric acid. (2) Although these seams may not be deep on the original wire, they are accentuated by the stretch which the surface of the wire undergoes during the cold-heading operation. (3) Such cracks are likely to be still further accentuated in hardening, and in many cases they will cause the ball to split in half.

In making a study of the effect of seams and scratches on the steel, it is the practice, as previously mentioned, to etch the stock with 20 per cent hydrochloric acid for fifteen minutes. After this has been done, it is passed across a grinding wheel having a face width of only 1/16 inch, care being taken to impart a combination rotary and transverse motion to the stock so that a helix is described on the surface, as shown in Fig. 32. This is preferable to passing the wire across the wheel without etching, because the action of the acid first lays open any surface defects which may be closed so tightly by the pressure of the cold-drawing operation that they will be invisible to the eye unless subjected to the acid treatment. The acid also makes the cracks black, and subsequent grinding exposes the white surface of the adjacent metal so that the crack is brought into as great prominence as possible.

Testing for Seams in Stock by Application of Pressure

Recently another test for revealing these seams has been developed, which consists of upsetting short blanks cut from the bars. These test blanks are 7/16 inch high and are ordinarily subjected to a pressure of 20,000 pounds, which results in flattening them out to a height of 3/16 inch, or to a pressure of 50,000 pounds, which flattens them out to a height of 3/32 inch. In all cases where there are seams in the wire, these test samples are split open by this pressure, while a perfect wire without any seams is not damaged by the treatment. At *A* in Fig. 33 are shown a sample cut from wire containing a seam and the same blank partially and fully upset; it will be noticed that, although the seam in the wire is small, it has been widened out considerably by the upsetting. At *B* in the same illustration is shown a similar set from perfect wire, comprising a blank and partially and fully upset samples, and it will be seen that the upset sample does not show any tendency to split.

In order to give some idea of the extent to which the seam at *A* was deepened by the upsetting treatment, section a–b through the blank and section c–d through the flat disk were polished, and photomicrographs of these are shown in Fig. 34. At *A* in Fig. 34 the seam in the original wire was about 0.010 inch in depth, while at *B* the depth of the seam after the blank has been upset has been increased to approximately 0.050 inch. From this it will be apparent that seams in the wire that do not appear to be of sufficient depth to give trouble may become very objectionable because of the tendency to deepen during the conversion of the stock into ball blanks. Upset disk *B*

Fig. 30. General View in Physical Laboratory. Attention is called to Brinell Hardness Testing Machine, Shore Scleroscope and Camera for taking Photomicrographs

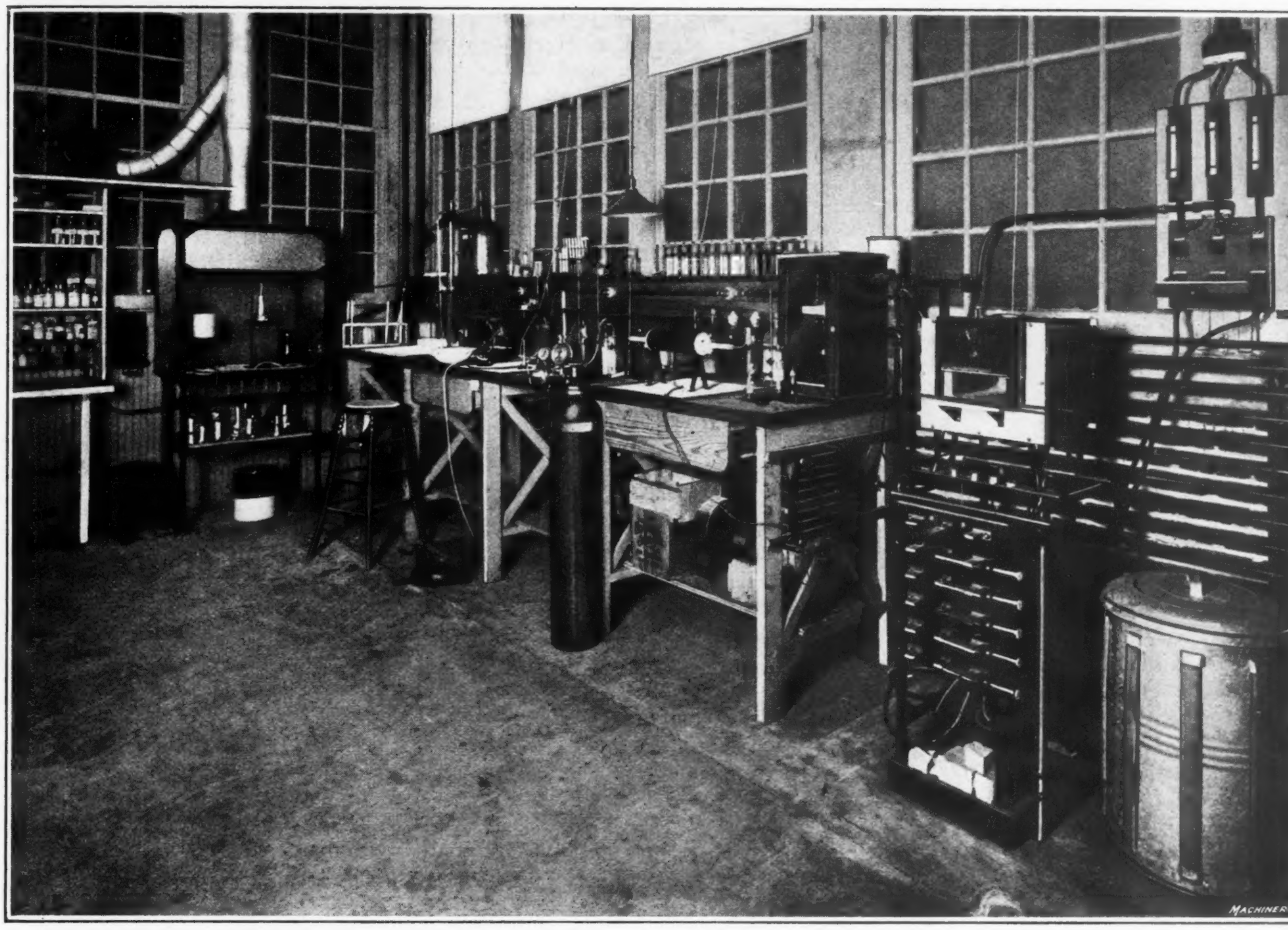


Fig. 31. General View in Chemical Laboratory, showing Apparatus for making Analyses of Steel, and Electric Furnace used in conducting Special Heat-treating Operations

is of about the same diameter as a ball blank made from this wire by the cold-heading process, so that it has been subjected to about the same amount of stretch in upsetting that would ordinarily take place in making a ball blank by the cold-heading process. To show how trouble may develop in this way, a ball 0.375 inch in diameter is produced from a blank 0.400 inch in diameter, so that the blank is reduced 0.025 inch on the diameter, or approximately 0.013 inch on the radius. This leaves 0.050 minus 0.013, or 0.037 inch of the split extending below the surface of the finished ball, which will certainly lead to its rejection by the inspectors.

It appears that hardness of the wire does not cause splitting of the upset blank. Tests conducted with a view to establishing this fact have shown that blanks made from seamless steel with a high Brinell hardness number did not split under the most severe conditions of upsetting, while blanks of metal with a low Brinell hardness number, but with seams on their surfaces, were frequently split during the process of cold-heading. Specifications under which steel is purchased for the production of ball blanks in cold-heading machines call for metal with a hardness number not exceeding 170 as determined by the Brinell method, but slightly harder stock is capable of being worked with fairly satisfactory results.

How Seamy Stock Acts in Cold-heading Machine

In order to confirm the accuracy of the conclusions reached in regard to the action of seamy stock when worked up into ball blanks in the cold-heading machines, tests were conducted by placing coils that had bad seams in them on the cold-headers and observing the kind of ball blanks that were produced. In every case it was found that the blanks produced from such stock showed bad cracks, as shown at *A* in Fig. 35. In the inspection department, cracks found in finished balls are commonly referred to as "fire cracks" on the assumption that they were developed during the process of heat-treatment, but they should really be designated as "header cracks." In this illustration attention is called to the fact that at the top and bottom of each ball blank there is a small projection formed by pressing the metal into the knock-out pin hole in the header dies. These have been termed "poles," and it will be noted that the poles lie on the axis of the wire. Midway between the two poles there is a band or "fin" caused by the metal being forced out between the two header dies; and this fin has been termed the "equator" of the ball.

It will be noted at *A* in Fig. 35 that the header cracks run from pole to pole. At *B* in the same illustration are shown some finished balls with the same kind of cracks, and it has always been found that cracks in the finished balls have been lengthened to a considerable extent, the ends of these cracks terminating in very fine lines. This is due to the fact that a small crack or fine sharp tool mark on a piece to be hardened causes a weak spot which in many cases will result in splitting the piece during the process of heat-treatment. At *A* in Fig. 36 are shown some balls that were picked out in the inspection department because they had fire cracks; these were sent to the laboratory and fractured to reveal the grain of the metal. It will be noticed—particularly in the third ball of the third line—that at the extreme left of the fracture there is a dark spot near the surface, which is the mark left by the original crack produced during the cold-heading operation. Then to the extreme right there is a fresh fracture which represents all the metal that the ball had to hold it together after being hardened.

Attention is called to the fact that the middle of the ball is black and oily; this is the hardening crack into which the oil and abrasive have found their way during the oil-rolling and grinding operations. It is believed that the crack produced in cold-heading was undoubtedly the cause of a further cracking of the ball during the process of heat-treatment. At *B* in Fig. 36 are shown some finished balls that were rejected by the inspectors because of cracks. Before being photographed these balls were etched with hydrochloric acid, and it will be noticed that the cracks run from pole to pole, and in some cases there are also secondary cracks following the line of the equator. The way in which these equatorial cracks are produced can best be explained by reference to a longitudinal section of the wire shown at *A* in Fig. 37, which has been etched with hydrochloric acid to reveal the structure of the metal.

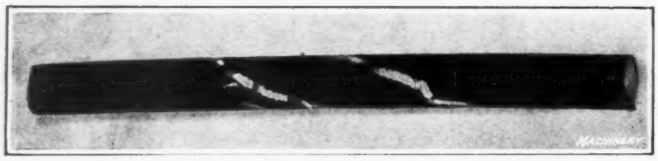


Fig. 32. Sample of Steel "Wire" etched and ground to show Seam

Attention is called to the lamellar structure, which is characteristic of any steel and is no reflection upon its quality. These laminations run lengthwise of the coil. At *B* is shown a section of a headed ball blank made from a piece of this wire and etched with acid to bring up the structure of the metal. Here it will be seen that the laminations have arranged themselves in a manner similar to magnetic lines of force running from pole to pole.

At *D* and *E* are shown header-cracked ball blanks, and it will be noticed that blank *E* shows an unusually large fin on one side. Blank *D* shows the split on one side and also a portion of the split extending into the fin. Blank *F* is properly headed and shows no crack or excessively large fins. Referring to the view shown at *C*, which is a cross-section of blank *D*, it will be seen that the split extends into the fin, and it will also be noted that the crack extends below the surface of the ball, although it comes to the surface at each end at points near the poles. This is due to the fact that the split does not penetrate the ball at right angles to the surface, but runs on a slant. Instead of compressing and filling up the open space in the ball, material has been pressed outward and

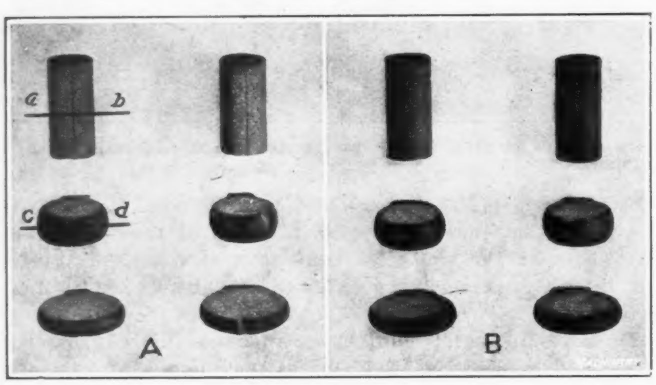


Fig. 33. (A) Samples cut from Steel with Seam in Surface, and Same Samples partially and fully upset, indicating how Seam opens up through Application of Pressure; (B) Similar Samples from Steel without Seam, which show No Tendency to split

made a large fin; when this fin is ground away, the crack is quite evident. At *G* and *H* are shown finished balls that have been etched with acid to show the grain at the equator and at the poles, respectively.

Referring again to the sectional view of the wire shown at *A* in Fig. 37, and also to the cross-section of a ball blank made from this wire shown at *B*, it will be seen that the structure of the steel has been greatly disturbed during the process of cold-heading to produce the ball blank. In Fig. 38 is shown diagrammatically the way in which this disturbance takes place. It will be seen that the ends of the fibers come to the surface at the poles and at both sides of the equatorial fin; and when the ball is etched the steel is attacked more rapidly at these points. The peculiar marks shown at *G* and *H* in Fig. 37 are the result of this disturbance of structure. The conclusion has been reached that when a ball with so-called "fire cracks" is etched with acid and shows two end poles and two equatorial marks with a wide crack running from pole to pole and a secondary crack running between the two equators, this crack is a header crack which is caused by a seam or lap in the steel from which the ball was made.

A number of these balls with header cracks were heated in an electric furnace in the laboratory and quenched in water at 1500 degrees F.; every ball was further cracked by this treatment, and several of them fell in half or were easily broken by a light hammer blow. Another lot of balls with no header crack was heated in the electric furnace and quenched in water at 1600 degrees F., and not a ball was cracked in

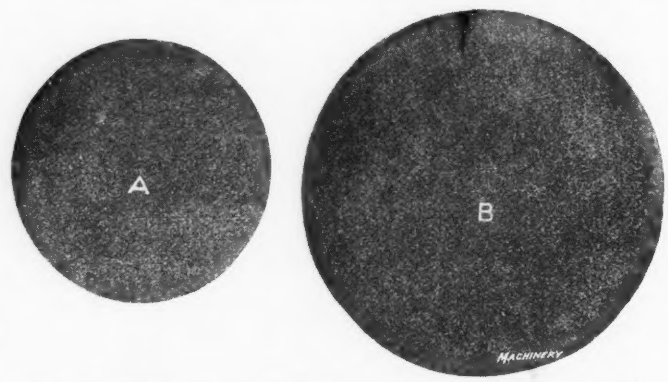


Fig. 34. Photomicrographs of Sections on Lines a–b and c–d in Fig. 33, indicating Increase in Size of Seam through stretching of Metal Surface in upsetting

hardening. Balls quenched in water at 1500 degrees F. that broke during the process of heat-treatment are shown at *A* in Fig. 39, while the balls quenched in water at 1600 degrees F., without damage are shown at *B* in the same illustration. At this excessive temperature the grain of the metal was coarsened, but no hardening cracks were produced and it required considerable force to break the balls. Several finished balls were next selected in the inspection department that showed very slight header cracks. These balls were hardened at 1500 degrees F. and cracked in the process of hardening exactly as before. The characteristic black mark left by the original header crack is shown at one side of the balls at *C* in Fig. 39. Another lot of finished balls showing no header cracks was hardened at 1600 degrees F. and none of the balls was cracked, views of the fractured surfaces of these balls being shown at *D* in Fig. 39. This confirmed the accuracy of previous tests, and from these data the following conclusions were drawn: (1) The header crack forms a weak spot, so that when the ball is hardened, even at the proper temperature, what the inspectors call a "fire crack" is likely to be produced. (2) A ball with no header cracks can be hardened at an excessively high temperature without producing a fire crack.

Another hardening test was made with four samples of wire, two pieces of which showed seams, and two pieces that did not. The seamy pieces of wire were quenched at a temperature of about 1500 degrees F. in water and hardening cracks developed along the seams. The two pieces without seams were quenched in water at a temperature of 1600 degrees F. and no cracks

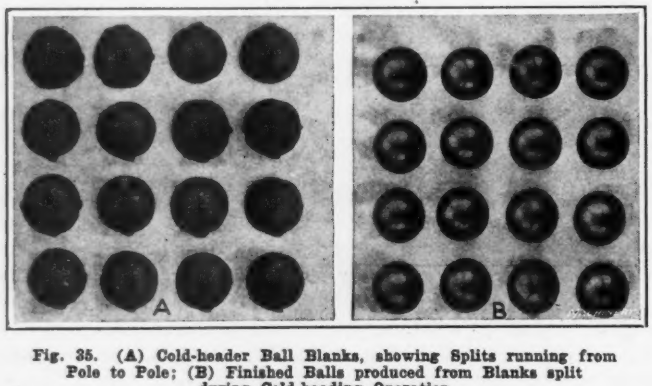


Fig. 35. (A) Cold-header Ball Blanks, showing Splits running from Pole to Pole; (B) Finished Balls produced from Blanks split during Cold-heading Operation

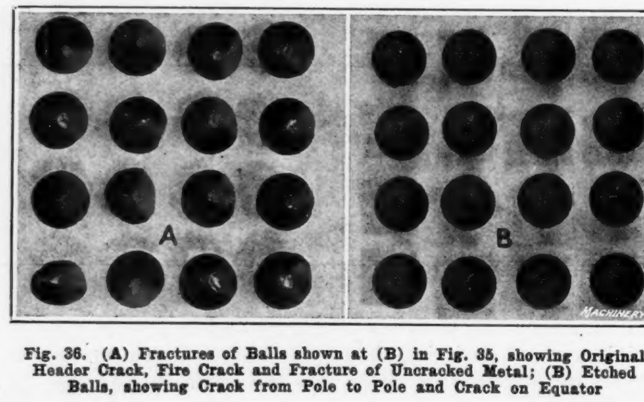


Fig. 36. (A) Fractures of Balls shown at (B) in Fig. 35, showing Original Header Crack, Fire Crack and Fracture of Uncracked Metal; (B) Etched Balls, showing Crack from Pole to Pole and Crack on Equator

developed. All these tests show that with small blanks without any header cracks, it is practically impossible to produce fire cracks in the automatic hardening furnaces; when cracks are produced they are started in cold-heading and not through the process of heat-treatment. The shape of the ball is in its favor, as it insures uniform quenching and a minimum of internal strain. Application of too high a temperature would tend to increase the size of the grain in the steel and make it brittle, but it would not produce hardening cracks.

Effect of Hardness of Wire

When the wire used in making ball blanks on cold-headers is too hard, there is a tendency for it to break off instead of shearing as it should. When trouble of this sort is encountered, it is likely to be accentuated by the fact that the blank is often carried to the heading die in a sidewise position, which results in the development of abnormal pressure in the die. Working hard stock of this kind is likely to result in breaking the cut-off knife or the dies on the cold-heading machine. This condition of excessive hardness does not usually exist for the entire length of the coil; wire may shear off and head nicely for some time, when suddenly a hard spot will be reached

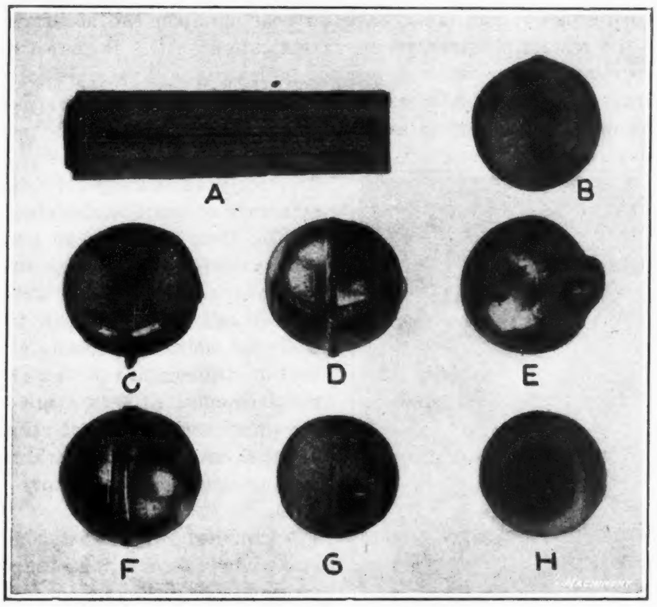


Fig. 37. (A) Section of Steel Stock, showing Lamellar Structure; (B) Cross-section of Cold-header Ball Blank, showing Distortion of Steel Structure; (C) Cross-section of Header Cracked Ball Blank; (D) Ball Blank shown in Cross-section at (C); (E) Cold-header Ball Blank with Large Fin; (F) Perfect Cold-header Ball Blank; (G) Etched Ball, showing End Grain of Steel at Equator; (H) Etched Ball, showing End Grain of Steel at Pole

and then the dies or the cut-off knife is likely to suffer. After this hard spot has been passed, the wire may be all right for another period of considerable duration. With the view of showing the relative condition of hard and soft spots in the wire, slugs of metal were selected at a point where trouble was encountered from this cause, and again at a point where the operation of the cold-header was entirely satisfactory. These were tested by the Brinell method and it was found that the hard slugs had a Brinell hardness number of 215, while the soft slugs only showed a Brinell hardness number of 190. The latter is really higher than it should be, as 170 is specified for steel to be used in cold-heading machines.

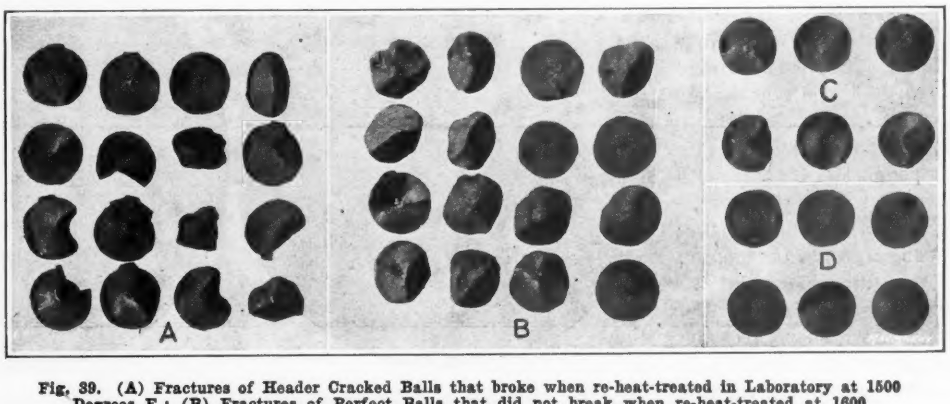


Fig. 39. (A) Fractures of Header Cracked Balls that broke when re-heat-treated in Laboratory at 1500 Degrees F.; (B) Fractures of Perfect Balls that did not break when re-heat-treated at 1600 Degrees F.; (C) Fractures of Balls with Slight Cracks which broke when re-heat-treated at 1500 Degrees F.; (D) Fractures of Perfect Balls that did not break when re-heat-treated at 1600 Degrees F.

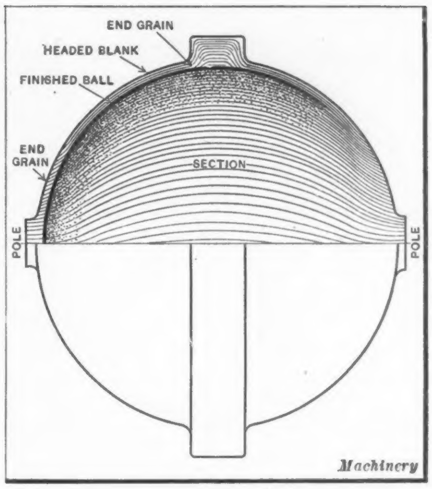


Fig. 38. Diagram illustrating Distortion of Steel Structure in Cold-header Ball Blank similar to that shown at (B) in Fig. 37

At *A* in Fig. 40 is shown the fresh fracture of a slug of hard metal, and attention is called to the coarse grain as compared with the finer grain of the normal steel shown at *B*. The hard specimen was very brittle and easy to break, while the normal steel was tough and capable of bending considerably before being broken. Specimens of these two steels were next polished and etched, with the results shown at *C* and *D*, respectively. These are transverse sections cut through the wire, and attention is called to the coarse grain of the steel shown at *C*; the ring at the surface is a band of decarbonized steel produced by the application of too high an annealing temperature. The normal steel shown at *D* has a fine grain and there is no indication of decarbonization, although what appears to be a band at one side of this section is in reality a thin oxidation film caused by the etching reagent.

At *A* in Fig. 41 is shown the decarbonized band of steel surrounding section *C* in Fig. 40, which is magnified to 62 diameters, instead of 5.25 diameters, as in the case of the previous illustration. It will be noted that the extreme edge of this photomicrograph is somewhat indistinct, owing to the slightly rounded edge formed while polishing the specimen. The decarbonized surface of this stock would not be entirely removed in the process of grinding, and would result in the production of either soft balls or balls with soft spots. At *B*, Fig. 41, we have the condition where there is practically no loss of carbon at the surface, with a proportional increase in the size of grains, although this is not enough to cause trouble. At *A* and *B* in Fig. 42 is seen a decided contrast between the structure of the slug of hard metal and that taken from the normal wire. At *A* there is a pronounced pearlitic structure with distinct cell boundaries of excess cementite, which also indicates the application of too high an annealing temperature. At *B* the structure is fine grained, which is the condition produced by employing the proper annealing temperature. Where lack of uniformity is discovered in the hardness of the wire, it is probably due to application of too high an annealing temperature.

Cause of Soft Spots on Balls

Some valuable discoveries have been made in the laboratory as a result of work that was started with some other object in view. For instance, an investigation that was started with the view of determining the effect of slight seams found in a certain shipment of steel at the time of the preliminary tests. These seams were not considered serious enough to justify rejection of the steel, but after the first lot of blanks had been finish dry ground, tests

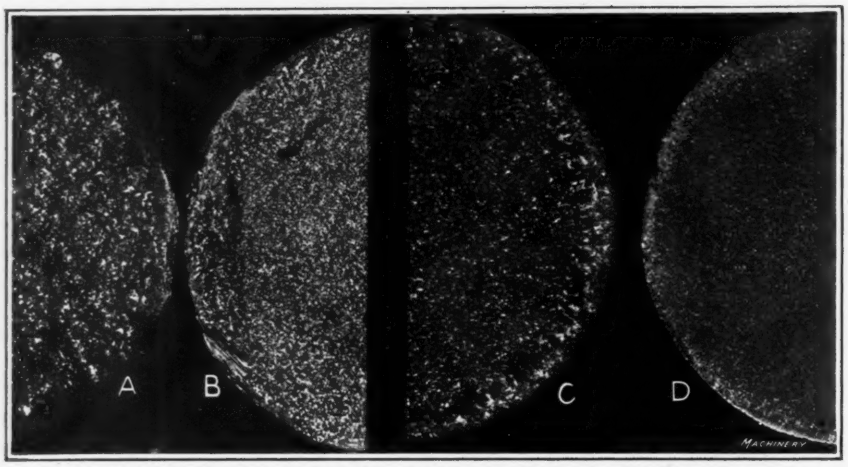


Fig. 40. (A) Fracture of Hard Metal Slug; (B) Fracture of Normal Metal Slug; (C) Etched Surface of Hard Steel magnified 5.25 Diameters—Attention is called to Decarbonization at Circumference; (D) Etched Surface of Normal Steel with No Decarbonization at Circumference

were made. This was done by etching a number of balls in hydrochloric acid, to see if the seams had been removed in grinding. The balls were immersed in the solution until they assumed its temperature, and after being etched for fifteen or twenty minutes they were removed, washed in water and brushed.

When treated in this way, the balls are usually a light gray color over their entire surface, but the particular lot of balls referred to could not be uniformly etched. At first it was thought that a film of grease or some other foreign matter was interfering with the action of the acid, but a second trial resulted in the same mottled appearance of the etched balls. Part of the surface was light gray, while other parts were dark gray and almost black. Balls with these spots are shown in Fig. 43, and no matter how often they were re-etched, the same spots always appeared and they were of the same outline as those developed by the previous etching. Some of the unetched samples were examined, and it was found that a considerable quantity of black scale was left on the balls, *i. e.*, the forging had not been cleaned up properly after the finish dry-grinding. At this stage the ball consistently measured 1.135 inch, *i. e.*, within 0.010 inch of the finished size—1⅛ inch.

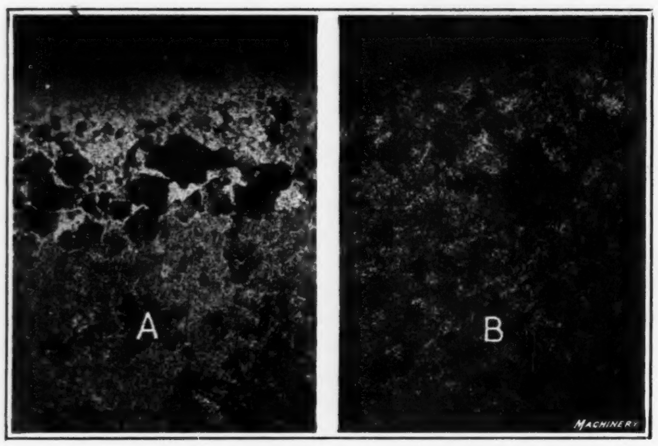


Fig. 41. (A) Decarbonized Surface shown at (C) in Fig. 40 magnified to Sixty-two Diameters; (B) Same Magnification as at (A), showing Condition of Practically No Decarbonization

Thus far results seemed to indicate that the forging blanks were under size, so five samples were selected at random and measured. The measurements of these five blanks are given in Table 4, reference to which will show that dimension *A* across the poles and dimension *B* near the poles were of ample size; and the surfaces at or close to the poles were also smooth and well filled out. However, these conditions did not exist around the equator, where it will be seen that dimension *C* was scant in many balls, and additional trouble was caused by the fact that the surface was very rough and covered with "hills" and "valleys." In making these equatorial measurements with a micrometer, the distance is taken across the tops of the "hills," while the dimensions in the "valleys" will obviously be considerably less. It is doubtful, therefore, whether three out of five of these samples would clean up in the rough dry-grinding. A re-examination of the etched dry-ground balls showed that the peculiar black spots did not appear at the poles as frequently as they did at the equator; and when a new file was applied to the black spots shown in Fig. 43, it was found that they were dead soft, while the light gray spots were very hard. The scleroscope hardness of ten of these balls was taken and averaged as follows: black spots, 48; gray spots, 70.

The reason for these spots will be understood from the photomicrographs presented at *A* and *B* in Fig. 44, which are taken from polished surfaces at the extreme outer surface of the black and white spots on the balls. These surfaces were prepared and photographed in exactly the same way; instead of polishing a flat on the ball, the spherical surface was polished, because a flat surface having any width whatever would also be at a considerable depth below the surface of the ball, and would not reveal conditions that it was desired to investigate. Difficulty was experienced in polishing this spherical surface, and so the photographs reproduced in Fig. 44 show polish marks rather too distinctly, but these have no bearing upon the accuracy of the results obtained in the investigation. At *A* is shown a large percentage of free ferrite, indicating a hypo-eutectoid structure of about 0.30 to 0.40 per cent carbon; in other words, the metal is similar to a mild steel. On the other hand, the condition revealed at *B* is practically a pure eutectoid structure of pearlite, this steel having from 0.85 to 0.90 per cent carbon. Specifications under which the steel is purchased call for from 0.85 to 0.95 per cent of carbon, so that in this regard it fulfills requirements. At *B* in Fig. 44 is illustrated steel of the original carbon content, while *A* illustrates the decarbonized steel.

A further test was conducted by preparing flat surfaces on the balls and examining these under the microscope; and in both cases it was found that photomicrographs obtained in this way indicated metal containing its full percentage of carbon. Hardness tests show that the metal directly under a decarbonized spot is soft and indicate not only that the decarbonized surface fails to harden, but that it also forms a sort of insulator and retards the proper hardening of the eutectoid steel beneath it. Therefore, the decarbonization plus its effects means a soft area of decided depth, so deep, in fact, that when the ball is finished the soft spot still appears.

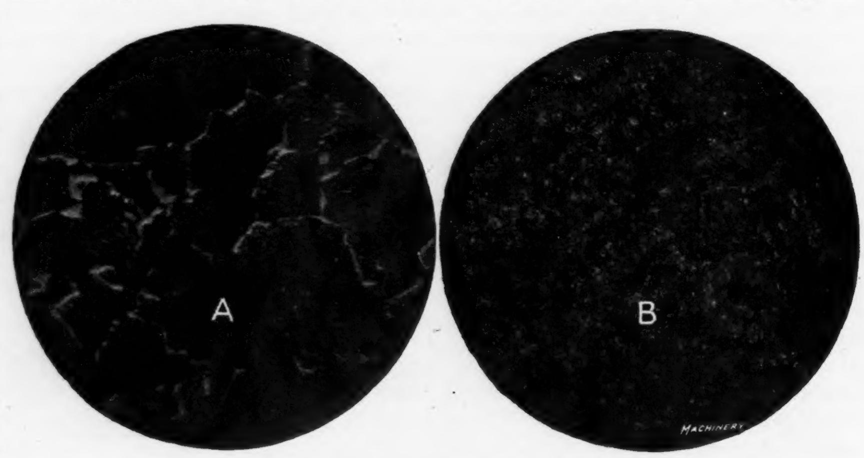


Fig. 42. (A) Pronounced Pearlitic Structure with Distinct Cell Boundaries of Excess Cementite, indicating Application of too High an Annealing Temperature; (B) Fine-grained Structure, showing Condition obtained with Proper Annealing Temperature. Both Samples magnified to 225 Diameters

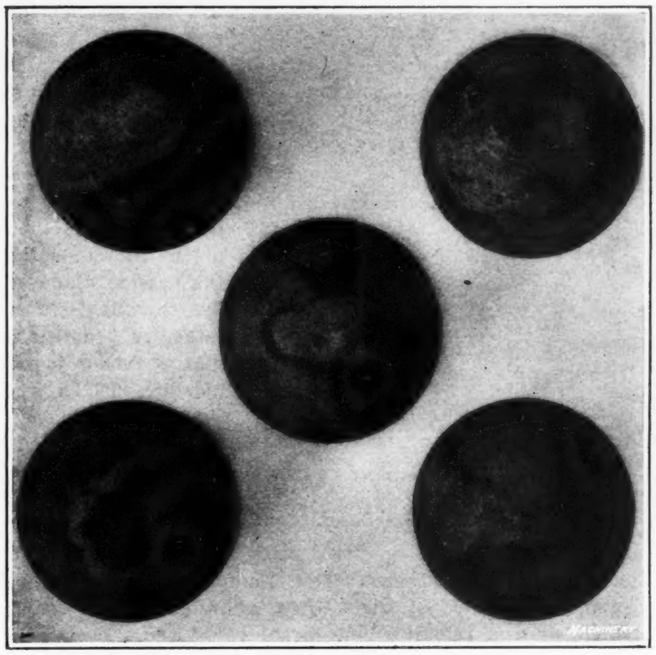
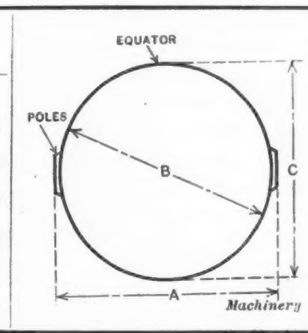


Fig. 43. Finish Dry-ground Balls after being etched with Hydrochloric Acid, showing Mottled Appearance due to Soft Spots produced by Decarbonization of Steel

Having reached this conclusion, specimens of the raw material were prepared by cutting sections transversely from the bar, and these were prepared and photographed, Fig. 45 illustrating the conditions that were revealed in this way. It will be noted that the steel shown at *A* is decarbonized to a depth of 0.010 inch — 0.020 inch on the diameter of the ball—while in the sample shown at *B* there is no decarbonization. It was this steel with the decarbonized surface that produced balls showing soft spots in the tests.

TABLE 4. MEASUREMENTS OF BALLS ACROSS POLES, NEAR POLES AND AT EQUATOR

Sample	A	B	C			
1	1.169	1.167	1.166	1.161	1.160	1.166
2	1.166	1.165	1.161	1.157	1.163	1.162
3	1.168	1.155	1.151	1.145	1.145	1.150
4	1.169	1.175	1.175	1.172	1.170	1.159
5	1.170	1.168	1.152	1.170	1.158	1.167



Fifty of these balls showing soft spots were taken to the laboratory, where they were again heat-treated, and the result was that the balls came out hard. It was not considered, however, that this indicated defective heat-treatment in the process of manufacture, because it might have happened that the operation of finish dry-grinding removed enough metal from the surface so that the balls would harden properly, although they were prevented from doing so at the time of the original treatment by the decarbonized steel that covered the surface of the balls. Because of the oval shape of the forgings, the depth of decarbonization varies at different spots on the rough-ground surface of the balls; for example, at the poles there is little or no decarbonization, while around the equator the decarbonization is quite deep. When a ball is reduced to the finished size, the following conditions will be found: (1) decarbonized areas where the original decarbonization on the rough ball was deep; (2) soft areas where the original decarbonization on the rough ball was shallow; (3) hard areas where there was little or no decarbonization on the rough ball. In cases (2) and (3) the steel has its full percentage of carbon, and when the balls are rehardened some of the soft spots disappear, while the spots devoid of carbon still remain soft. It would be possible to reduce these balls to a smaller size and reclaim them by rehardening, but this subsequent heat-treatment makes the balls shrink and also has a tendency to roughen their surface slightly, which necessitates subsequent grinding operations that would probably reduce the diameter from 0.015 to 0.020 inch, so that allowance must be made for this reduction in size.

To overcome trouble from the use of stock that is decarbonized at the surface, special forging dies were made which produce oversize ball blanks, so that the diameter at the equator measures from 0.060 to 0.080 inch more than that of the standard finished balls. The same stock forged in a regular die would make a blank 0.025 inch to 0.035 inch larger than the finished size. In the present case it is found that these would not clean up, but left soft and decarbonized spots on the surface of the finished ball. For this reason, the special forging dies were produced. This practice was adopted because, owing to the slow deliveries made by the steel mills, it was desired not to reject any steel that could possibly be used.

Development of a Device for Separating Hard and Soft Balls

Owing to shipment to the factory of a large quantity of low-carbon steel through an error made at the steel mills, about seven tons of this material was converted into ball blanks before it was attempted to harden them. This was due to the fact that a large supply of blanks of the same sizes had accumulated, and these were naturally sent through the heat-treating department ahead of blanks made from this shipment of steel. When the blanks had been heat-treated, they were tested in order to determine the nature of the results obtained, and while a number of balls broke with a fine-grained fracture and showed a hardness that was all that could be desired, almost 10 per cent of the balls were found to be dead soft. When these balls were subjected to pressure they flattened out instead of breaking in the usual way. A peculiar mottled effect was noted on the balls found to be file hard, while the soft balls were a dull black color; but this difference in appearance was not sufficiently marked to enable the balls to be separated, and even had this been possible, the length of time required to eliminate defective balls by this method would have been prohibitive.

With a view to overcoming this difficulty, a device was developed which is shown in diagrammatic form in Fig. 46. Its principle of operation is based on the fact that when balls are dropped on a hardened steel anvil there is considerable difference in the height of the rebound of hard and soft balls.

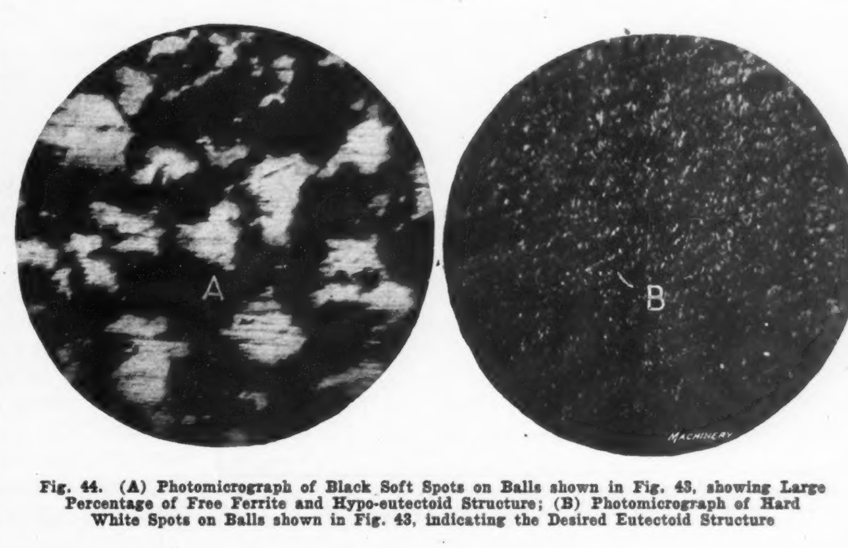


Fig. 44. (A) Photomicrograph of Black Soft Spots on Balls shown in Fig. 43, showing Large Percentage of Free Ferrite and Hypo-eutectoid Structure; (B) Photomicrograph of Hard White Spots on Balls shown in Fig. 43, indicating the Desired Eutectoid Structure

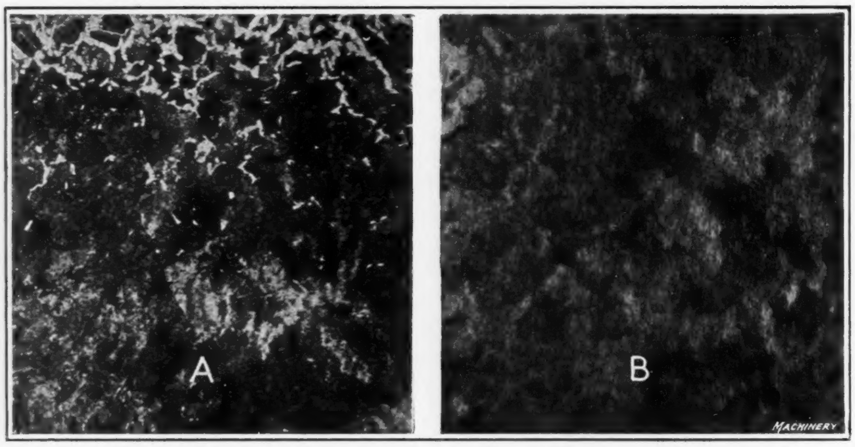


Fig. 45. (A) Photomicrograph of Transverse Section of Decarbonized Edge of Steel—Magnification, 125 Diameters; (B) Photomicrograph of Transverse Section of Steel showing No Decarbonization—Magnification, 125 Diameters

The balls to be tested roll down an inclined plane and drop upon a hardened steel block, from which they rebound; the hard balls rise high enough to pass over a "hurdle" into a box, while the soft balls do not reach this height and are deposited in a second box. To test the efficiency of this device, 119 balls taken from one of the tote pans in the shop were run through the drop test; 79 dropped into the "hard bin" and 40 into the "soft bin." These balls were once more thoroughly mixed and again run through the apparatus with the same result as in the previous case. Additional trials confirmed the accuracy of the apparatus. This method of separation proved so satisfactory that a regular equipment is now being built for use in the dry-grinding room, where it will be used for separating hard and soft balls.

Conclusion

Many of the cases of trouble to which reference has been made are of rare occurrence, but it is obvious that they exert a powerful influence on the quality of the product turned out in the factory. Also, the conditions brought to light by these investigations are exceptionally interesting. It was on this account that they were selected for discussion in the present article, in connection with the regular work of the laboratory, and not because they really belong to a description of routine work of testing the raw material and product of a factory engaged in the manufacture of steel balls.

* * *

MAKING PISTON RINGS

BY B. T. HAWLEY [1]

I was required to make some snap piston rings to fit an air-compressor cylinder 8 1/32 inches in diameter, the piston-ring groove being ½ inch wide. Wishing to profit by the experience of others, I sought data on piston-ring design, but found nothing that would help, so I made the ring as follows: A hard gray-iron casting was obtained from a pattern that had an inside diameter of 7 7/8 inches, an outside diameter of 8 3/8 inches and a length of 4 inches. The inside of the casting was not machined, so that the scale might be left for spring. The casting was chucked in a lathe 1/16 inch off center, giving a run out of 1/8 inch, and the outside diameter was turned to 8 1/4 inches. The rings were then carefully cut off 0.01 inch longer than the finished dimension with a parting tool, and ground on a surface grinder to a close fit in the piston-ring grooves. Next, a slot 3/8 inch wide was milled through the thinnest part of the piston-ring at an angle of 45 degrees with the face. A simple fixture was then made for finishing the outside diameter by chucking, in a lathe, a cast-iron disk 8 inches in diameter. This was permitted to protrude from the chuck 1 inch, and a shoulder 7.315 inches in diameter and 3/8 inch long was turned on its end. A clamp washer, the outside diameter of which was 7 7/8 inches, was fitted to this disk and drawn on with four cap-screws. The cut rings were placed on this shoulder and the ring ends drawn together with a rawhide belt lace. Then, while each ring was held so that its thickest part hugged the turned diameter of the fixture, it was turned with a scraped finish to the exact diameter of the cylinder, and finished except for a few thousandths of an inch, which was filed off the ends of the rings when they were being fitted to the cylinder.

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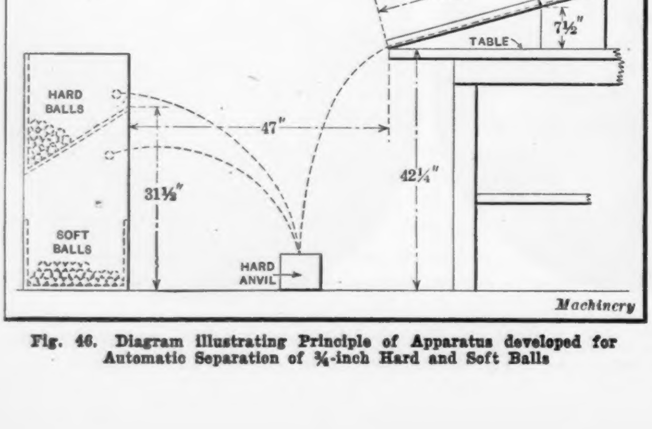


Fig. 46. Diagram illustrating Principle of Apparatus developed for Automatic Separation of ¾-inch Hard and Soft Balls

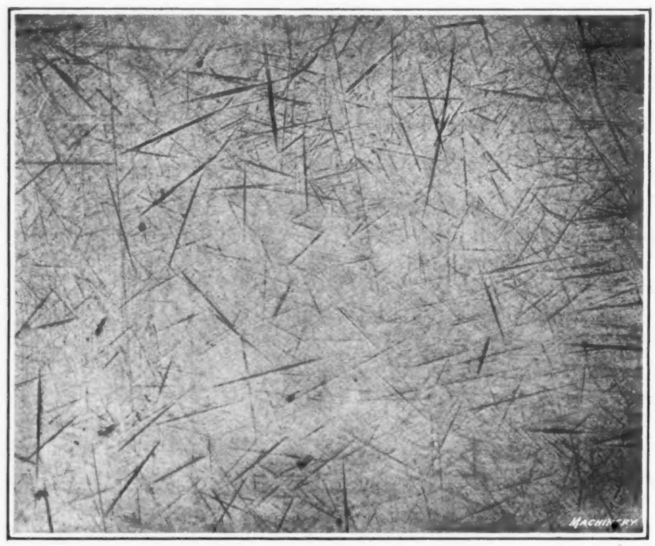


Fig. 47. Highly Magnified Surface of Polished Ball, showing that under Best Conditions Surface is covered with Multitude of Scratches

* * *

MACHINERY IN WARFARE

The European war is characterized by the use of machinery on a larger scale than has ever before been experienced in warfare. The so-called "tanks" used by the British in the operations on the Somme are the latest developments of machinery applied to destruction. These tanks are armored caterpillar tractors, which by reason of their design are able to traverse areas impossible to negotiate by ordinary wheel vehicles. H. G. Wells, the well-known British writer, predicts that if the war continues tanks will be developed to enormous size and power, and will be the most terrible agents of destruction ever known. He visualizes monsters weighing many hundreds of tons, driven by engines of enormous power and tracking many yards in width. These gigantic land battleships would be practically irresistible in their onward march. They would level and crush fortifications, buildings, forests, and other obstacles, and the very land itself would be so cut to pieces as to be worthless for agricultural purposes or other uses for years to come. What this war will bring forth in the way of destructive agencies it is hard to say, but the heavy gun of mobile type seems to be the most effective weapon.

USE OF DIAGRAMS IN MACHINE DESIGN[1]

VALUE OF ANALYSIS OF MECHANICAL MOVEMENTS IN LAYING OUT AUTOMATIC MACHINES

BY J. W. WUNSCH [2]

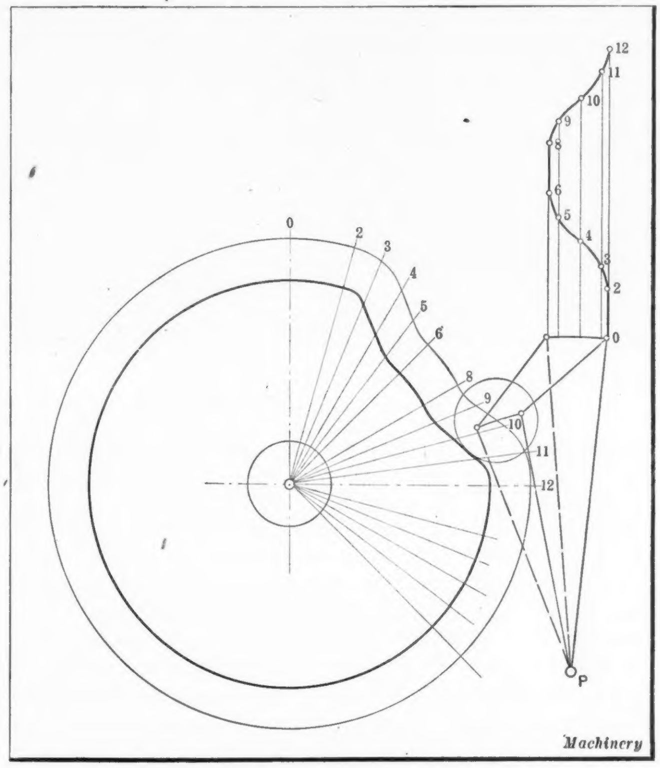


Fig. 1. Analysis of Movement of Simple Cam

A DIAGRAM, in machine design, is the graphical representation of one or more movements or functions of a mechanism through a complete cycle or any part of one. A diagrammatic analysis of the movement of a simple cam is shown in Fig. 1. There is nothing new about such a chart, yet if it were used more universally in designing, cams that are right the first time would be the rule rather than the exception. The cam lever is centered at *P*, and the chart clearly shows the character of the movement imparted to it.

A diagram illustrating the functions of a mechanism through a complete cycle is shown in Fig. 2. The device is employed in a blood-pump for the transfusing of blood from one person to another. It is practically a two-phase valve, as shown at *A*; at *B* its operation is illustrated schematically. In one position it transfuses blood from the donor to the recipient and in the other it transfuses the saline solution to the donor. The latter position is the one illustrated.

A diagram of every function and movement for a sheet-feeding device is shown in Fig. 3. A few of the most interesting movements will be analyzed and the reader can easily figure out the others for himself. The beginning of the feeding action is similar to the manual turning of a leaf in a

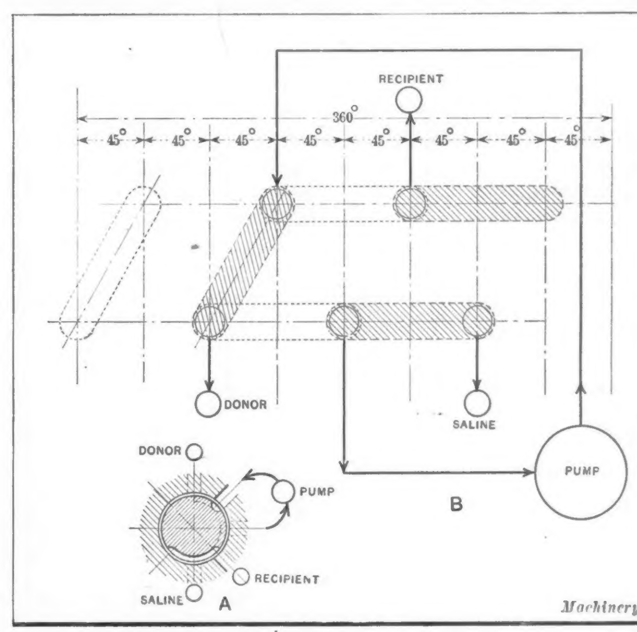


Fig. 2. Illustration of Operation of a Blood Pump

book. The feed fingers, one of which is shown in Fig. 4, come down on the sheet and feed it forward, then are lifted from the table and return for the next sheet. Curve *A*, Fig. 3, illustrates the forward and backward motions and curve *B* the

[1] See also "Design of Automatic Machinery," in MACHINERY, August, 1916.
[2] Address: 1581 Lincoln Place, Brooklyn, N. Y.

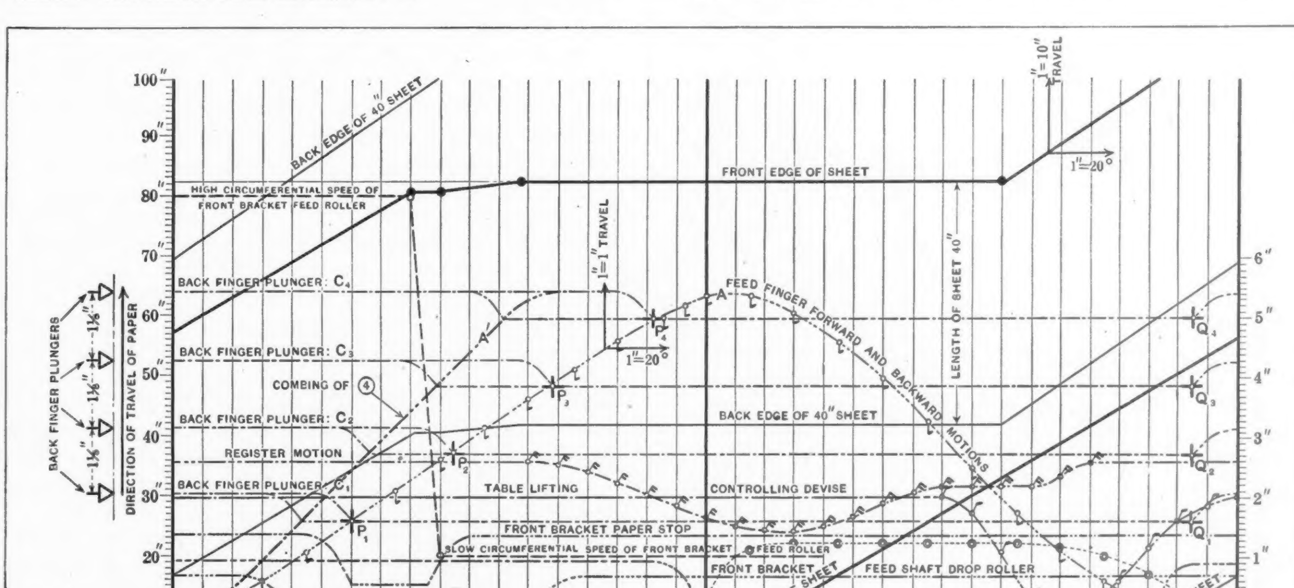


Fig. 3. Diagram of Movements of a Sheet-feeding Device

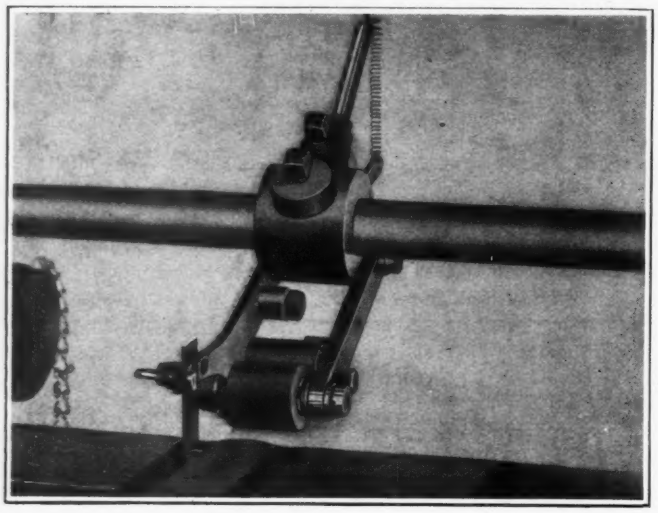


Fig. 4. Feed Finger of Sheet-feeding Device

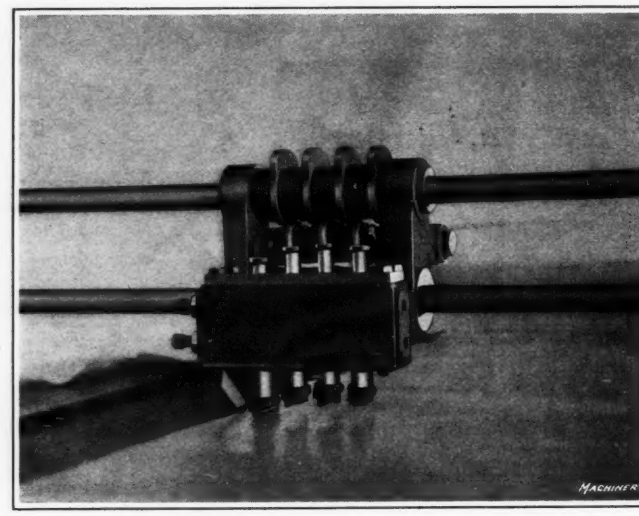


Fig. 5. Back-fingers of Sheet-feeding Device

lifting and lowering. It is interesting to note in curve *B* that the feed rollers leave the paper very quickly (about 35 degrees) and descend on the next sheet, moving forward very gradually, that is using about 80 degrees of the cycle. The function of the back-finger plungers shown in Fig. 5 is to insure that only one sheet is fed at a time. These fingers are actuated by cams, and drop successively on the table. The curve C_1, Fig. 3, shows the movement of the first back-finger plunger, C_2, the second, and so on. It will be noticed that the first finger drops on the sheet after one-sixth of the cycle is completed, the second finger somewhat ahead of it, the third finger ahead of the second, and so on. These positions are indicated at P_1, P_2, P_3, and P_4. All back-finger plungers rise simultaneously a little before the feed fingers descend to feed the sheet; these positions are indicated at Q_1, Q_2, Q_3, and Q_4.

Fig. 3 also illustrates one reason for charting curves on one diagram; that is, it shows the degree of adjustability. There seems to be no good reason why cams on special machinery should have to be "doctored" to perform properly, as they invariably must be. This may be entirely prevented by proper

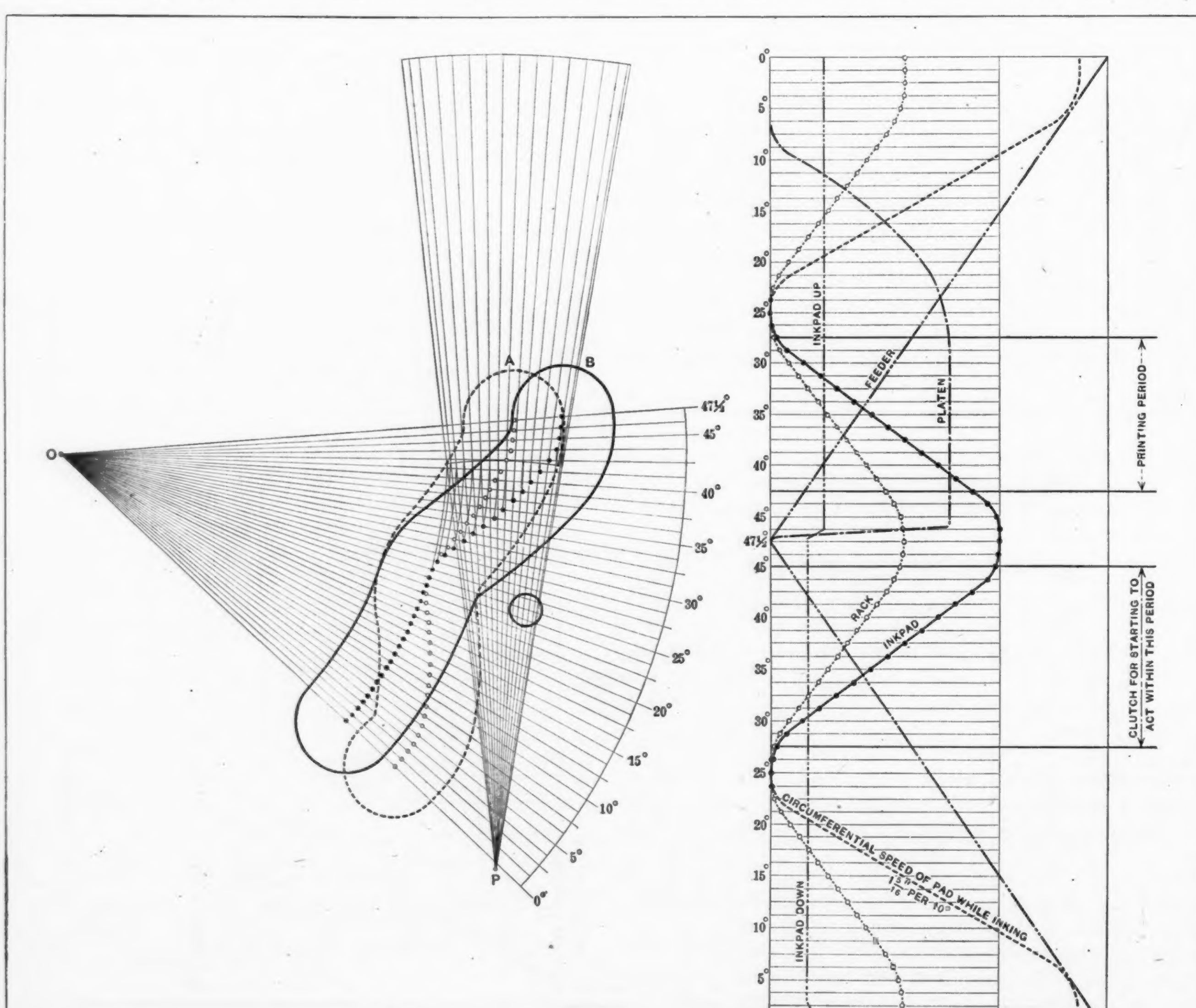


Fig. 6. Diagrammatic Analysis of a Reciprocating Mechanism

diagrammatic investigations before the cams are made. However, related movements should, whenever possible, be obtained with a certain degree of adjustability to compensate for any changes that may be required, due to unexpected behavior of the articles handled. It will be noted that, from such a diagram as that shown in Fig. 3, the limits of adjustability of any movement may be discerned at a glance. For example, suppose it is desired to lift the back-finger plungers from the table later in the cycle; it will be seen from curves A and C_1, C_2, C_3, and C_4 that there is about 18 degrees of adjustability in this direction. Obviously it would not do to make this movement later than 18 degrees, since the feed fingers will have already dropped on the table and will be moving the sheet forward.

A reciprocating mechanism operating within 47½ degrees is illustrated in Fig. 6. It consists of two groove cams A and B, which are centered at O and actuate cam levers pivoted at P. The function of cam A is to operate a rack in a special printing machine. Cam B operates an ink-pad in the same device. In this illustration these movements are also analyzed diagrammatically, together with several other related functions. It will be noted that since these movements are charted with relation to the fulcrum O, the entire operation takes place in 47½ degrees forward and 47½ degrees return; yet this mechanism has completed its cycle in this interval.

* * *

MACHINING A SPRINKLER HEAD

BY JOHN J. BORKENHAGEN[1]

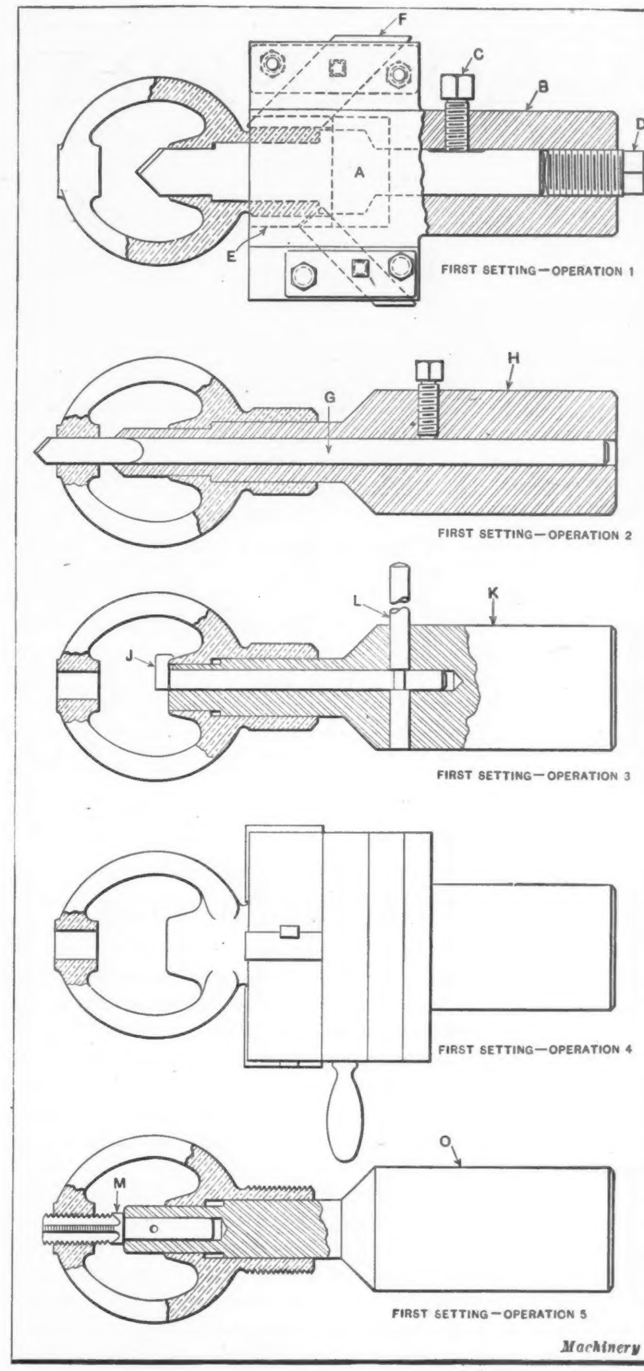
The method of machining a sprinkler head described in the September, 1916, number of MACHINERY seems to the writer to be too long. Further, the use of the nut and washer to hold the head in the second setting would be likely to cause a burr to be raised on the seat which would result in a leak in the head when assembled. Some time ago the writer machined 36,000 heads by the following method at an average production of 700 per day. Out of lots of 1000 that were tested at 500 pounds water pressure, less than one per cent was scrapped. A two-jaw chuck was used, with openings in the sides for the chips to drop through. The work was done as follows:

First Setting

Operation 1—In the first operation the head is turned, faced to length, the hole roughed out and the end of the head chamfered. The hole is roughed out and the head faced by a flat counterbore-drill A held by set-screw C in a cast-iron box-tool B. Another set-screw D prevents the drill from sliding backward. The hardened bushing E is provided for guiding the end of the sprinkler head as it enters the box-tool. The turning tool F is set in the box-tool at an angle, resting in a milled slot and a set-screw prevents it moving. The chamfering tool is held in the opposite side of the box-tool in a similar manner.

Operation 2—In this operation the hole is reamed to the two diameters by a four-lip combination reamer H and the hole is drilled at the other end of the sprinkler head by drill G. The center of the combination reamer is drilled out to take the drill G, which is held in place by a set-screw.

Operation 3—This operation consists of back-facing the inner surface by a special tool. The hook tool J is located eccentrically with the body of the tool K. The shank of the hook tool extends into the body of the holder for a considerable distance and a handle L is inserted in it. The tool body is milled away, providing a slot to rotate the handle L 180 degrees, thus revolving the hook tool to a position where the entire device may be removed from the hole in the work. The shank of the tool and the handle are fitted snugly to the holder K to prevent chattering. The hook tool J is turned and milled, and the cutting edge roughed out. After the roughing of this cutting surface, a hollow mill is used which accurately governs its shape. By keeping the edge of the hook tool sharp, which is necessary to prevent a leak when the head is in use, the writer completed, on an average, from 3000 to 4000 pieces in the life of each of the hook tools. A suitable stop was used on the carriage of the machine in which this job was performed to limit the backward movement of the hook tool, thereby governing the amount of material removed from the seat.



Operations in First Setting of Sprinkler Head

Operation 4—In this operation the thread is cut on the outside of the sprinkler head by means of an ordinary self-opening die-head. By turning the die-head upside down in the carriage and leaving the handle low enough to hit the carriage when revolving the turret, the closing of the die is accomplished automatically.

Operation 5—This operation consists of tapping the small hole in the farthest end of the sprinkler head. A simple brass tap-holder O fits the previously reamed hole and guides the tap M, which is soldered to it.

Second Setting

In the second setting, the top of the casting may be faced in a drill press by a four-lipped facing tool, thus completing the machining of the sprinkler head.

* * *

The number of motor and passenger vehicles exported from the United States during the last fiscal year was 77,496. The number exported in 1915 was 37,876; in 1914, 29,090; and in 1911, 11,803.

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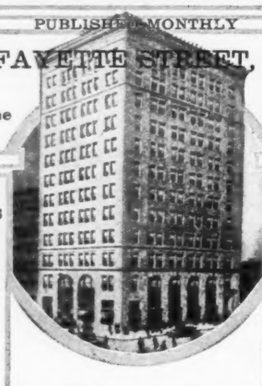

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NOTCHED HAMMER HANDLES

A well-known manufacturing firm in the Middle West had hired a number of men to work in its blacksmith shop, and while making his rounds shortly after this addition to the force, the superintendent stopped to speak to one of the new employes. During the course of their conversation, he inquired the reason why the hammers in this man's kit of tools were notched in a peculiar way; and with a directness which was commendably frank, but somewhat lacking in diplomacy, the new blacksmith replied:

"I have used those hammers for a good many years, and the notches on each handle are what I call my 'pay gage.' When I get thirty-two and a half cents an hour I hold the hammer at the notch nearest the head; for thirty-five cents an hour I hold the handle one notch nearer the end; for thirty-seven and a half cents an hour I take hold still one notch farther from the hammer head; and when I get forty cents an hour I take hold at the end of the handle."

It happened that the superintendent of this plant was a man who made quick decisions, and as his firm was badly in need of blacksmiths and hampered by the impossibility of getting forgings as rapidly as they were required, he decided to try an experiment with this new blacksmith. Having reached this decision, he said:

"As you were holding your hammer handle somewhere around the third notch at the time I came along, I judge your present rate of pay is about thirty-seven and a half cents an hour. Now I have decided to try you out on a different scale of wages. You take hold at the end of that hammer handle, and if you can earn the money, at the end of the week your pay envelope will be filled at the rate of forty-five cents an hour."

Every man who is familiar with conditions in American manufacturing plants knows that efficiency is being greatly hampered because a large percentage of the employes are using hammers with notched handles. This is due to a variety of causes, and an important one is that many employers of labor make a practice of basing wages upon general experience with men hired for doing a given class of work, rather than upon results of a study of the quantity and quality of work produced by individual employes. Men are hired as milling machine operators, lathe hands, blacksmiths, etc., and are given a specified rate of pay upon which they are likely to continue, because that is the rate that has always been paid for the job on which they are engaged.

If the turning out of more work and work of a better quality than that ordinarily done were the means of securing higher wages, there would be more ambition among mechanics to stand high in the regard of their employers; and they would progress more rapidly toward positions of responsibility. That success followed the experiment of the superintendent is attested by the fact that his new blacksmith is still working at the rate of forty-five cents an hour.

* * *

USE OF PORTABLE TOOLS IN MANUFACTURING

Portable tools, except pneumatic hammers and electric drills, which have a recognized field of use in erecting bridges, buildings and other structures, are generally regarded as makeshift means for doing repair work on parts that cannot be conveniently taken down and carried to stationary machine tools. But this conception is not altogether sound, as portable tools are being used successfully for the manufacture of machinery. A few months ago a new concern organized in the West for building a line of machine tools was confronted by the practical impossibility of obtaining regular equipment in time to build the machines it had agreed to furnish, and its general manager was forced to develop new means and methods for machining the castings, the result being the production of a number of portable machines that have been used with entire satisfaction.

In building machine tools especially, it is feasible to do machining operations following planing with comparatively small and inexpensive portable machines supported on the planed surfaces. Then holes bored with fixtures supported on the planed surfaces may be used for locating and holding the tools for subsequent operations. Portable tools offer several advantages, among which are the following:

The frame is machined in its working position and not lying down, thereby eliminating flexure; a portable tool can be set up on the casting in less time than the casting can be set up on a machine tool; the actual machining is done in less time, as the tools are set ready for work; and the shop capacity is greatly increased at moderate outlay, as the portable tools generally take the place of large expensive tools. Another important advantage is that often two or three different operations can be performed simultaneously on the same lathe bed or other machine frame.

The principal disadvantage of portable tools is that they require operators who must be skilled mechanics. Machine operators having had experience on repetitive work only are not suited to this work without special training. The men must be experienced, have good judgment and be adaptable. Of course if manufacturing along these lines were highly specialized and the quantity of work to be done were large, it would be feasible to train operators to do certain jobs as effectively, probably, as on stationary machine tools. There is a field for highly developed and accurate portable tools not generally seen by the average machine builder.

* * *

AN INTELLIGENTLY SELFISH EMPLOYER

Once upon a time a liberal minded general manager said, when making a yearly settlement with his traveling representative, "John, I wish this check that I am handing you for commission accrued over and above your weekly drawing account was more." The check was a large one—to some managers it would have seemed entirely too large—but this manager's attitude was intelligently selfish. If the traveling representative had earned more, *his* profit would have been more. Too few employers of labor recognize the great truth that the more their men earn, the greater their profits will be, if the business is properly managed. The employer who fixes an unchangeable day rate of pay for his employes is short-sighted and may generally be regarded as a poor manager. He does not recognize the fact that his employes are properly cooperators and not servants.

DEFECTIVE MACHINERY

BY CHESLA C. SHERLOCK [1]

The general rule of law is that a manufacturer or vendor is not liable to third parties, who have no contractual relations with him, for negligence in the construction, manufacture, or sale of articles which he handles. This rule has been supported for generations by the courts and the decisions on the point would cover many volumes. The theory that no man has a right to sue another upon a contract or an implied contract, unless there is a contractual relation between them, is a relic of the old English common law.

The advent of our present age of industrialism presented situations to our courts which were never contemplated by the common law. It was found that in many instances manufacturers could produce a product of inferior quality, both in material and workmanship, sell it to wholesalers and jobbers, and escape all liability for any injury resulting from its inferiority. The courts justly came to the conclusion that exceptions to the general rule were in order, so that during the last ten or twelve years we have had some new laws on this subject which is of vital importance to all who are engaged in the manufacture or sale of machinery. These exceptions, as generally recognized by the courts, are limited to three. The first is where the manufactured product itself is imminently dangerous to human life. A manufacturer engaged in the business of producing a machine or a product that, in itself, is dangerous to human life is bound to use the best material and the utmost care in workmanship, if he would escape liability to any third party who may purchase or use his product. The courts have not been content to let the matter rest at this point. They have gone further and said that if a machine, itself, was not imminently dangerous to human life, but that if, through inferior material or unskilled workmanship, it is rendered dangerous to human life, the same liability will attach to the manufacturer.

The second exception to the general rule is where the manufacturer invites or induces the injured party to use the defective product or represents it to be safe and sound. Of course, this does not mean that the manufacturer personally must make the representations. It means that either he or his selling force or agents may make the false representations so as to hold him for the injury done.

The third exception to the rule is where the manufacturer knows that defective material or workmanship is being used, but takes steps to conceal such defects by the use of paint, putty, or other means so that they cannot be discovered.

In any one of these exceptions, the manufacturer of machinery will be liable to third parties for injuries sustained, regardless of whether there is privity of contract between them or not. Deceit is an important element in this new line of decisions. The New York Supreme Court did much to blaze the way when it said:

> A manufacturer has a right to sell a defective machine if he gives notice of the defect to the purchaser, who, in turn, has the same right. Neither has the right, however, with furtive intent, to completely conceal the defect and sell the machine as sound and safe, intending it to be used as such by anyone into whose possession it might lawfully come, when the natural result would be the infliction of any injury upon any person who used it. By giving currency to the implement as safe, with intent to deceive not only the purchaser but any user, and yet so covering up the defect as to entirely conceal it, the defendant (a manufacturer) was guilty of an actionable wrong.

The real distinction between cases where the manufacturer is liable and where he is not liable seems to rest upon the character of the manufactured article itself. In general terms, it can be said that if the machine itself is dangerous to human life the manufacturer will be liable for any defect; if it is not of itself dangerous to human life, he will not be liable, in the absence of knowledge of its defective condition. It should be remembered, however, that the courts are leaning even farther and have come to the conclusion that even though the machine itself is not ordinarily dangerous, if the inferior materials used or unskilled workmanship renders it dangerous to life, the same liability will attach.

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LARGE RETURNS FROM SMALL TOOLS

BY J. W. T.

The writer recently spent several days inspecting the tool-room and tool cribs of a shop employing over 1500 men, of whom probably fifty were toolmakers. Some of the things he saw in this shop, which is credited with being strictly up to date, should be interesting and instructive to many readers of MACHINERY. This article is confined to the tool-room and tool cribs, but the methods of handling tools and men in this department will apply to the machine shop as well, and the conditions existing in this shop will be found in a large percentage of the shops in the country. The foreman of the tool-room, who has two assistants, complained that he had great difficulty in getting good men; that men came to him with first-class references, and started in as if they knew their business, only to fall down in a few days; or after working a day or so decided they did not want to stay. The result of the writer's inspection has given the foreman cause for reflection if nothing more.

Much care and money had been given to this department. Sheet-metal boxes and drawers, conveniently arranged and indexed, provided for a ready distribution of tools. But, and here is the first fly in the ointment, these tool cribs were handled by boys who were totally ignorant of the use of the tools; therefore, they were unable to give the tools the necessary care while in the cribs. To illustrate, there were forty-eight boxes provided for reamers, of which a large stock is carried. When these tools were received or given out, they were chucked into the boxes as if they were scrap. Careful inspection of over one hundred reamers failed to find one that was not nicked, with, in most cases, a burr projecting; and these reamers were expected to make polished bores. It was the same way with taps. Thirty or forty were thrown indiscriminately into a sheet-iron box without any thought being given to protecting the cutting edges; there was not one first-class tap in the crib, although a large proportion were new. Small milling cutters suffered to the same extent. Corners of teeth were broken off and dull cutters were placed with good tools. End-mills weighing over a pound were dropped over a foot into a sheet-iron box on top of others.

While these tools appeared to be ready for use, they really were not. Reamers had to be stoned before using and the toolmaker who overlooked this fact would spoil a hole in a piece on which he might possibly have spent a day or more. Or, if he did stone up the reamer, it cut just enough small to require an hour or two for lapping to size. A tap, which appeared to be new, would have the point of a tooth nicked off just enough to make it "hog" in when used on tool steel. Often the only milling cutter of a given size left in the crib had to be ground, and the man who was to use it had to wait the convenience of the cutter grinder. All these things cost money and are hard on the temper of many good workers; and foremen are paid high salaries to keep men in good humor. Now all these tools are received in a package that will stand severe shipment and can be stored in the cribs, in many instances at least, in the original package without taking up much more room. They may be kept in these packages when not in actual use. The foreman agreed with the writer that at least 50 per cent of the wear and tear on these three classes of tools can be saved in the tool crib.

In the tool-room, bolts, washers, and clamps for planers and millers were in bad shape. The bolts were without nuts and the clamps were distorted and not of proper design. A ten-minute milling job often required a half hour or more to get bolts and clamps. Collars on arbors were bruised and out of truth. Arbor-center adjusting screws were not oiled and stuck so that a wrench was necessary to move them. There were no wrenches to fit the nuts, except such as were kept in lockers by the older hands and considered private property. All these things made it extremely difficult for a new man to get started on work which, under proper conditions, would be very simple to do.

On lathes, the head centers were often found to be lower than the tail centers, making it practically impossible to ream a bore with the reamer held on centers. A lathe hand, on

being hired, was told that the shop furnished all the tools necessary and was given a patent tool-holder and two or three pieces of tool steel with which to do possibly a dozen different operations, each requiring only a minute to do; but five to ten minutes had to be consumed each time in grinding a tool from one shape to another. And there are some lathe operations in which such tools cannot be ground to do the work. End-mill sockets did not fit the spindles and draw-bolts would not fit, as the threads were worn off and the bolts were too short to cut new threads. Mills would work loose and dig into the work. Often, when this occurred, work which had taken over an hour to set up had to be moved in order to tighten the mill, and then reset and the cut picked up. It is often difficult to pick up a cut, and then a file must be used to get the required dimension and finish. This is disheartening to a new man. Belts were of improper size and dry. When a machine was pushed up to anywhere near its reasonable limit, the belt ran off. Then the operator had to send for the belt man and his ladder and wait until he arrived.

These conditions, which the writer feels safe in saying obtain in many of our shops, can be remedied at little or no cost. The resultant saving will boost dividends to a surprising extent. Many good workmen, who are now considered inferior, would prove money makers and the amount of spoiled work would be greatly reduced. Most shops are fairly well equipped with large tools, but many are far from being properly fitted with small tools and facilities for keeping them in serviceable condition. A tool not in condition to be used should never go into the crib. In 1901, the late Frederick W. Taylor, at a meeting of the board of directors of one of the shops of the Allis-Chalmers Corporation, said that in his opinion the three most important elements entering into shop production were equipment, labor, and supervision. Of these, he attached the greatest importance to equipment; and having worked under Mr. Taylor's direction several years, the writer knows he placed such equipment as that discussed in the first rank in importance. This small-tool equipment is the penny that grows to a dollar every six months, and strict attention to these details will make good workmen out of poor ones and superintendents out of foremen.

* * *

MACHINE TOOL REPAIRS

BY W. G.

The interpreting of orders for repair parts for machinery is a matter with which the writer has had considerable to do, and he has often asked himself: "When people require repairs, and particularly when they request immediate shipment, why do they not take sufficient interest in their own business to state what they want?" The writer encounters many cases of lack of adequate information. For instance, in today's mail is received an order from a large concern calling for "one compound rest for lathe." How the customer expects the manufacturer who receives the order to determine what is wanted is a question. Upon receipt of the order the question at once arose, "What lathe is it for?"; and next, "What part of the lathe does this customer call the 'compound rest'?" Of course, if the order clerk should hazard a guess, and not guess correctly, he would have to explain the reason for the guess. It is necessary, therefore, to take up the matter with the customer. In this case the reply was received without undue delay, which disclosed that two parts of the lathe carriage were wanted; but the other question as to what lathe the parts were for was ignored, though the customer emphasized his request for prompt shipment.

In the same mail, an order from one of the largest companies in this country read: "One each parts Figs. Nos. 4, 7, 11, and 13, as per blueprint No. 123,456." But the blueprint did not accompany the order, although the order stated that the material was wanted at the customer's works on the same day that the manufacturer received the order. Another order in that mail said: "One carriage for 36-inch lathe serial number 40,000. Don't need apron for gears." Investigation disclosed that the manufacturer's No. 40,000 was not for any part of a 36-inch lathe; hence an illustration was sent to the customer for the manufacturer's shop number of the lathe, and he was requested to indicate on the illustration what part he called the "carriage." In due time the illustration was returned, and, notwithstanding the fact that the customer was three thousand miles away, he only indicated what part he called the "carriage," which proved to be what the manufacturer calls the "tool-slide." Consequently, another letter had to be sent, and three weeks more was lost in an effort to learn what was required to fill the order.

Again, a firm may purchase a machine from a second-hand dealer, of which transaction the manufacturer has no record, and later may find a gear with some teeth missing. The probability is that the purchaser will write to the manufacturer, supposing that the machine is a metal planing machine, "Please express at once gear for our planer," with probably some description of what the gear is, but without any dimensions, number of teeth, or other information to aid in determining what the gear is or what machine it is for, and the customer fully expects the gear to be shipped as ordered. In the case of a metal planing machine with, say, four heads, it often happens that a part of one of the heads is broken. It is the exception rather than the rule, however, for the order for repairs to state for which head the parts are desired. Is it not reasonable to suppose that the shop engineer or any one else whose duty it is to specify for these repairs should know that the parts wanted are not common to any of the other heads, and should designate to his purchasing department for which head parts were needed?

These instances could be enumerated indefinitely. The point to which the writer wishes to draw the attention of the shop people is the great waste of time caused by the present system. In many cases it has taken from one to two months to have the customer supply the information necessary to fill his order, during which time the machine is out of commission, in addition to the time it then takes to fill the order; and it is possible that the use of this machine is worth from ten to one hundred dollars a day, depending on its size. This is an item to be considered when the machine is idle for weeks for the simple reason that definite, intelligent information is not furnished in the beginning, say, from the shop to the purchasing department.

The foregoing examples are ordinary cases, being handled by the writer daily. They lead to the conclusion that some purchasing agents word their orders according to the wording of the requisitions sent them. A description of the article or articles wanted is often misleading from the point of view of the receiver, because of the localism in the wording, but if the description were supplemented by a rough sketch, with the principal approximate dimensions, it would usually be possible for the manufacturer to determine exactly what is wanted and fill the order promptly. A sketch generally gives more information than lines of description. If the purchasing agent would insist upon the shop supplying, with its requisition, a sketch of the parts wanted, many of the present delays would be avoided and the machine would be placed in service much sooner. In most cases, when repairs are needed they are needed at once, in view of which fact it would seem as though the customer would take unusual pains to make clear to the manufacturer what was wanted.

Some years ago there was published an article that showed the lack of uniformity in the names of lathe parts; a piece is called by one name in one section, by another in another section, and so on, which makes a description indefinite and misleading. When definite information is furnished with an order for repairs, the manufacturer can enter the order for execution in less time than it would take to write for further information, aside from waiting for a reply, and enable shipment to be made much more quickly, and thus place the idle machine in operation making its daily profit. It should not take a mind reader of the Sherlock Holmes variety to determine what an order is meant to cover, nor should the manufacturer be expected to guess.

* * *

Although the tungsten deposits in California were discovered in 1913, they were not worked to any extent until the early part of 1916. Since then they have yielded large quantities of the mineral.

Portable Tools for Lathe Manufacture

by Edward K. Hammond[1]

MANY experienced machine tool builders and most engineers who have made a study of the methods employed in this line of manufacture, regard it as work which requires the shops to be fully equipped with planers, boring mills, milling machines, shapers and a variety of other standard machine tools. The nature of the work handled in machine tool building factories also makes it necessary to have tools of ample capacity, because the castings for the beds, headstocks, aprons and many other parts are of considerable size and weight. To those readers of MACHINERY who have grown accustomed to standard practice in machine tool building, it will come as a surprise to learn that the Phoenix Mfg. Co., Eau Claire, Wis., has been securing very satisfactory results in machining bed castings for Conradson engine lathes without using anything but small portable tools after the ways on the bed have been planed. It is the purpose of this article to describe the portable tools used for this purpose, and the economic conditions which made it necessary to adopt this method of machining. The special tool equipment was designed by C. M. Conradson of Eau Claire, Wis., and shows what gratifying results can sometimes be obtained by discarding generally established methods of machining in favor of individual methods especially developed to meet existing requirements.

Conditions which Led to Development of Special Tools

At the time that the Phoenix Mfg. Co. was preparing to engage in the manufacture of Conradson lathes, the demand for machine tools for use in manufacturing munitions was so urgent that it was a matter of extreme difficulty to obtain any sort of reasonable deliveries. Reference to the accompanying illustrations will show that the Conradson lathe is designed with the headstock cast integral with the bed of the machine, and the gearing in the head is carried in a cylindrical case or barrel that may be rotated in the cross-bore of the headstock to engage either a worm and wheel or a spiral gear drive to the spindle. Ordinary practice would be to bore the holes for the spindle bearings and for this gear-case on a horizontal boring machine, but a tool of this kind was not included in the equipment of the Phoenix shops. Inquiry among manufacturers of boring mills revealed the fact that they had booked orders so far ahead of their delivery dates that it would be at least eight months before a boring mill could be placed on the floor of the Phoenix shop in Eau Claire. This made it necessary either to develop some special means of machining or fail to take advantage of the great demand that existed for engine lathes, and after giving the subject some study, Mr. Conradson developed the portable boring-bars shown in Figs. 1 and 2.

This was the starting point in the development of portable tools for machining the lathe beds, and as it was subsequently found that builders of radial drilling machines and other machine tools, which would ordinarily have been purchased to equip the factory for lathe manufacture, were as badly off in regard to deliveries as the boring mill builders to whom application was first made, Mr. Conradson proceeded to develop a complete equipment of portable tools for conducting machining operations on the lathe beds and tailstocks. The following description outlines the different machining operations in the order in which they are conducted, and in each case a description of the special portable tool will be given with an explanation of the work for which it is used.

Boring Holes for Taper Bronze Spindle Bearing Boxes

It has already been mentioned that at the time work is started on the lathe bed castings with these portable tools, the ways have been planed, and these are used as reference points from which to locate the tools for subsequent machining operations. The first step is to rough-bore the taper holes for the bronze spindle bushings, which is done with a portable boring-bar shown in operation in Fig. 1. This outfit is used to bore the holes and face the inside and outside ends of the boss surrounding each bearing. Two rough-boring cuts are first taken in the holes, then a roughing and finishing cut are taken on the face surrounding the inside and outside ends of each spindle bearing, after which finishing cuts are taken through the bearing holes. The order in which these facing cuts are taken is as follows: First take roughing and finishing cuts on the inside of the rear bearing, and from this finished surface—after the roughing cut has been taken—gage across the open space in the headstock with a pin gage in order to finish the inside of the front bearing to the required position. Next take roughing and finishing cuts on the outside end of the rear and front spindle bearings, using snap gages to provide for taking the finish cuts to reduce these bearings to the required length. After facing the surfaces at each end of the spindle bearings, these bearings are finish-bored. The reason this finishing cut is taken after facing is because of the taper form of the holes to be bored, which obviously makes

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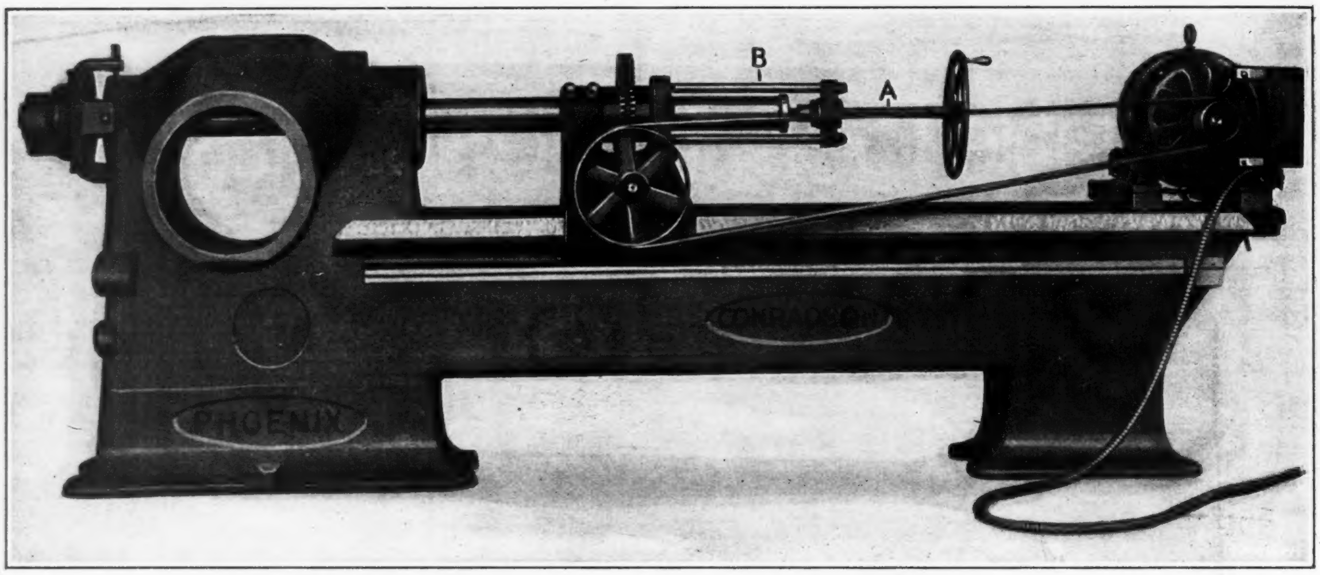

Fig. 1. Portable Boring-bar Equipment for boring and facing Spindle Bearings in Headstock

it necessary to have them properly located in relation to the finished faces.

The equipment with which these boring and facing operations are performed is shown in operation in Fig. 1, and it will be seen to consist of a carriage mounted on the planed ways of the lathe bed, which receives power from an individual motor drive. The boring-bar is driven by means of the worm-wheel shown, and feeding of the bar into the work is accomplished by means of screw *A*. Secured to the boring-bar carriage is a yoke *B*, through the end of which runs the feed-screw, although this screw is not threaded into the end of the yoke. It will be seen that the feed-screw is splined, and a sliding lock fitting into this spline provides for securing the feed-nut to the end of yoke *B*. In this way, power feed is obtained, and when it is desired to use hand feed the lock is disengaged so that feed-screw *A* can be turned by means of the handwheel carried at the end of this screw.

Construction of Boring-bar

A sectional view of the boring-bar used for machining the tapered holes for the bronze spindle bearing bushings is illustrated in Fig. 2, where it will be seen that two cutters *A* and *B* are provided to bore the two bearings simultaneously. These cutters are revolved by the bar in the usual way, and in order to obtain the desired taper for the bored holes, the effective radius of each cutter is varied as the cutters are fed through the work, by means of wedges *C* and *D* which run under clips that carry the boring cutters. The way in which this mechanism operates may be briefly described as follows: A spline groove cut in the boring-bar receives wedges *C* and *D*, and the remainder of the spline groove is occupied by filler strips *E*. In setting up the portable boring tool for operation, a collar *F* is mounted at the end of the headstock casting; this collar is held by clamps *G*, which fit into an annular groove, so that collar *F* is free to revolve with the boring-bar. Wedges *C* and *D* are free in the spline groove, but are prevented from moving longitudinally as the boring-bar is fed through the work by the combined action of collar *F* and filler strips *E*. The result is that cutters *A* and *B* run over tapered wedges *C* and *D*, and in this way the effective radius of the cutters is varied so that the holes are bored to the desired taper. It will be obvious that a bar of this kind could easily be constructed with wedges of any desired taper to meet the requirements of different boring operations. Facing of the inner and outer ends of the bearings is accomplished by means of facing cutters substituted in the bar in place of the boring cutters, but in this case wedges *C* and *D* are not required.

Boring and Facing Tailstock Bearing

For boring and facing the tailstock bearing hole, the same portable outfit is used, but for this operation a boring-bar of smaller diameter is employed. The method of performing this operation is illustrated in Fig. 3, where it will be seen that the tailstock casting is placed on the bed of the lathe between the boring-bar carriage and the headstock. The bar is then passed through the cored hole in the tailstock casting and piloted in a bushing in the spindle bearing of the headstock. When this has been done, two rough-boring cuts are taken through the bearing hole, after which the front and rear ends are faced off to reduce the bearing to the required length, which is determined with a snap gage. The illustration shows the facing head in operation, and attention is called to the fact that this is the same form of head that is employed on the bar for facing the ends of the headstock spindle bearings. For performing this operation, the connection with screw *A*

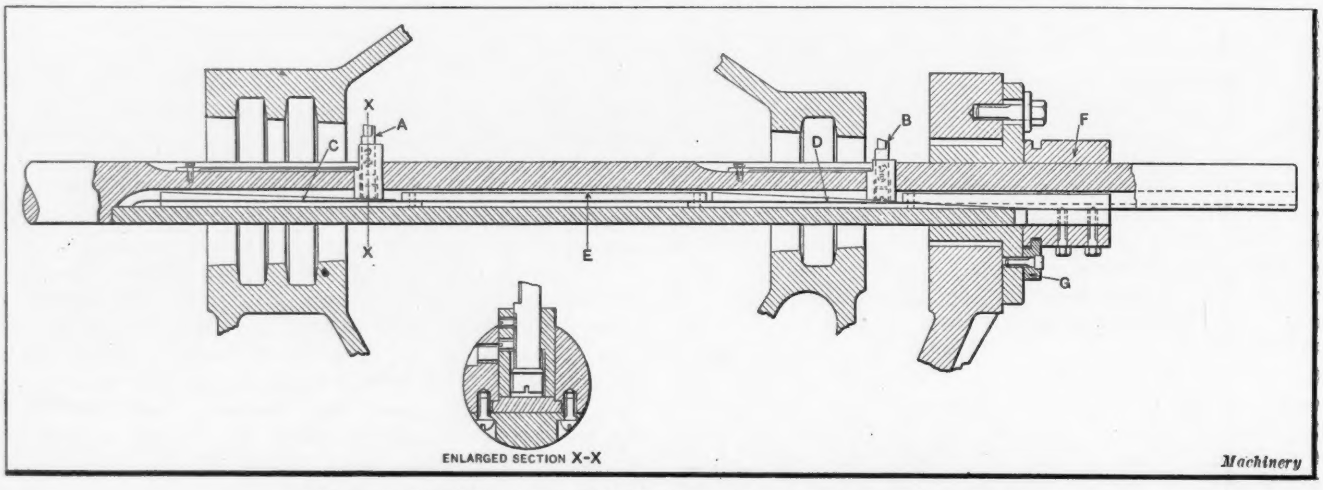

Fig. 2. Sectional View of Boring-bar for Taper Holes, shown in Operation in Fig. 1

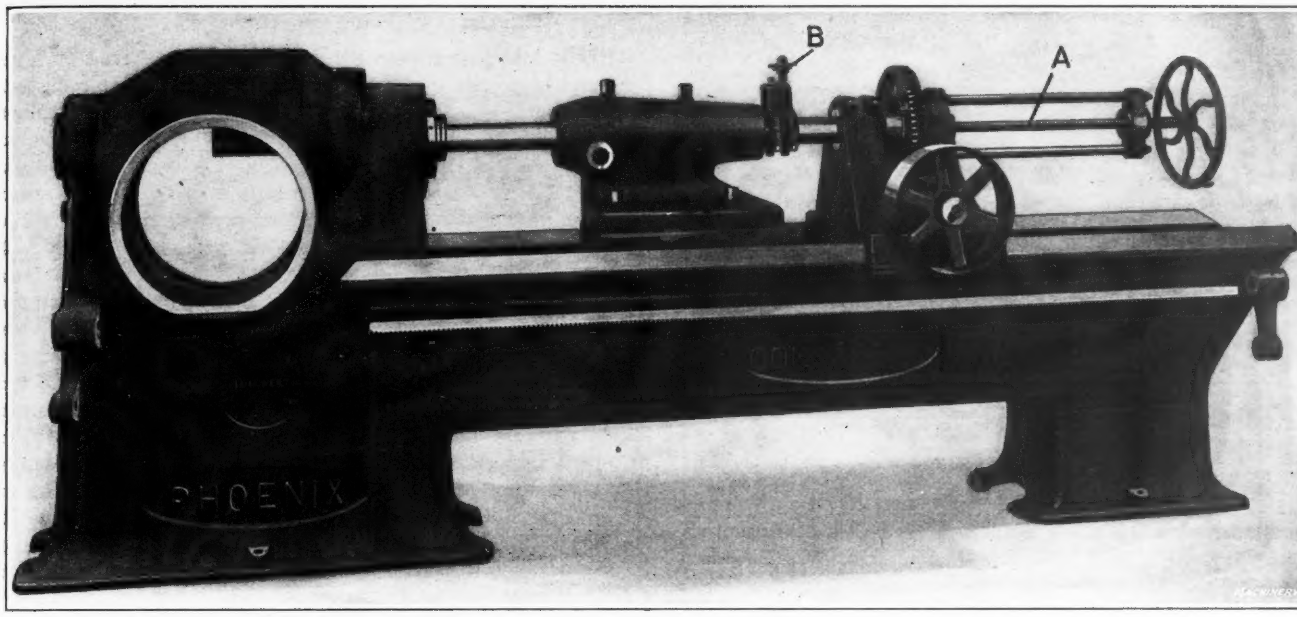

Fig. 3. Equipment for boring and facing Tailstock Spindle Bearing—Illustration shows Performance of Facing Operation

is disengaged and the facing cutter is fed to the work by means of a star-feed *B* on the head that engages a dog clamped at the rear of the lathe bed. After taking the finish-facing cuts, the facing head is removed from the bar and a finishing cut is taken through the spindle bearing, as in machining the headstocks.

Boring and Facing Gear-case Bearings

Next in the order of operations performed on the lathe bed comes the boring and facing of bearings for the gear-case in the headstock. Figs. 4, 5 and 6 show the portable tool developed for this purpose, which is driven by the same motor secured to the end of the lathe bed that was employed for driving the spindle boring fixture. A point of particular interest in the case of this cross-boring outfit is that provision has been made for performing simultaneously the boring and facing operations on the bearings at the front and back of the headstock. In order to explain the operation of this boring-bar, attention is directed to Fig. 6, which shows in detail the arrangement of the cutter-heads. The tool is supported in the lathe headstock by a bushing *A*, through which a bar is slipped, passing through the finished headstock spindle bearings.

It has been explained how the spindle bearings are bored with a tool that locates itself from the finished ways on the lathe bed, and as the supporting bar fitting into bushing *A* is carefully machined to fit accurately in the spindle bearings and in bushing *A*, it will be apparent that this location will result in boring and facing the gear-case bearings accurately in relation to both the ways and spindle bearings. The fixture is driven by means of planetary gears, which are arranged as follows: Pinion *B* is cut in a bushing keyed to the shaft on which the driving pulley is mounted, and this pinion drives a gear and pinion *C*, which will be seen to mesh with gear *D*. Gear *D* is secured to the casting of which bushing *A* is a part, so that it cannot rotate. As a result, the planetary gearing causes rotation of the cutter-heads for boring and facing the bearings at each side of the lathe headstock, these heads being mounted on the bar that extends right through the fixture. In each of these heads there is one boring and one facing cutter, the boring cutter in one head being shown at *E*, and the facing cutter in the opposite head at *F*. These cutters are mounted on slides so that the feeds may be obtained through screws actuated by star-feeds, the star-feeds *G* for the facing cutters being operated by dogs mounted on the ways of the lathe bed, while star-feeds *H* for the boring cutters are operated by dogs supported on stands placed on the floor at each side of the lathe bed.

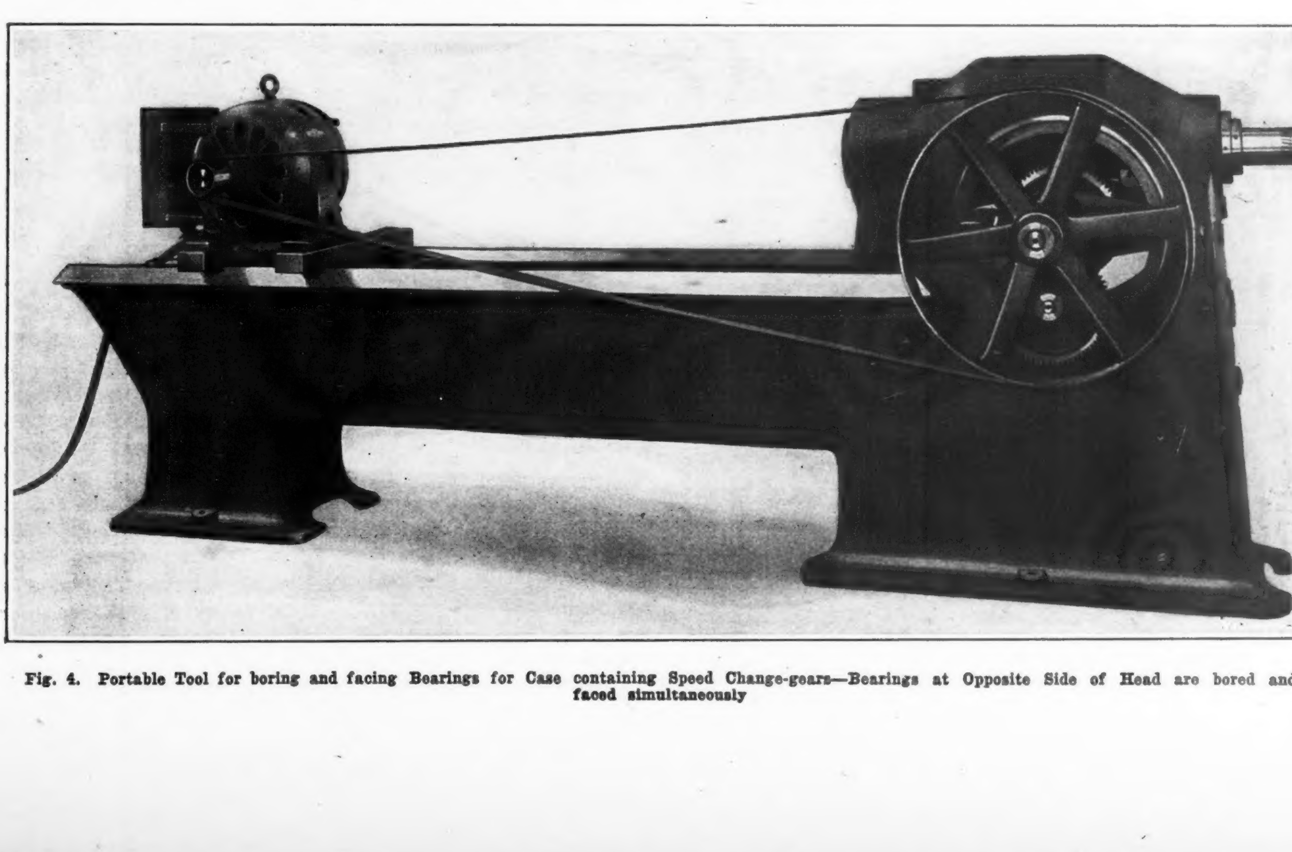

Fig. 4. Portable Tool for boring and facing Bearings for Case containing Speed Change-gears—Bearings at Opposite Side of Head are bored and faced simultaneously

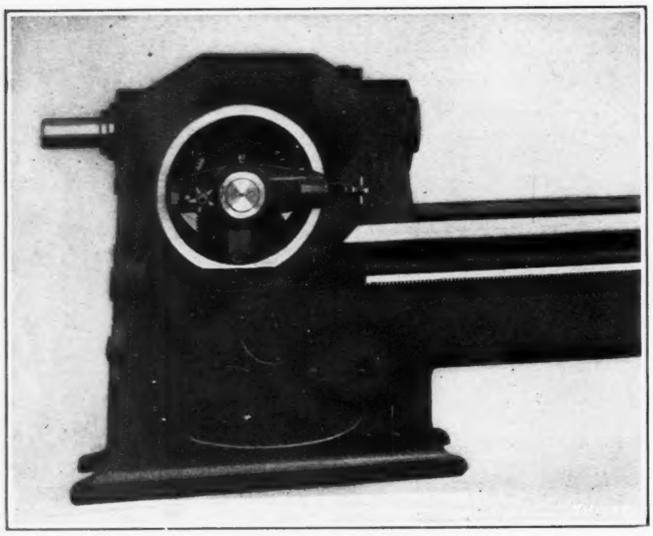

Fig. 5. Opposite Side of Boring Equipment shown in Fig. 4—Attention is directed to Star-feeds for Boring and Facing Tools

Radial Drilling Attachment for Drilling and Facing Operations on Headstock

The next step is to drill two holes at the top of each spindle bearing, which are required for the oil cups and for the screws used to secure the wedges that are employed for adjusting the tapered spindle-bearing bushings. For the performance of these drilling operations, a portable radial drilling machine is employed, which is shown in operation in Fig. 7. For mounting this tool, it will be seen that use is made of the same bar through the spindle bearings that was employed for supporting the cross-boring fixture shown in Figs. 4, 5 and 6. This bar locates the frame that rests across the ways on the lathe bed, so that location is obtained from both the ways and the spindle bearings. It will be seen that a jig plate *A* is used for locating the two holes that are to be drilled at the front end of the headstock. After drilling these holes, the radial arm of the drill is lifted off and transferred to post *B* at the opposite end, which is furnished with a jig plate *C* for locating the holes at this end of the work.

A brief description of this radial drilling machine will not be out of place. It will be seen that the drive is furnished from an individual motor, on the armature spindle of which there is a sprocket that transmits power by a chain drive having a ratio of 1 to 3. From this point, power is transmitted through a pair of spur gears having a ratio of 1 to 3, and thence through a spiral gear drive contained in case *D*, which also has a ratio of 1 to 3. In this way, the power is stepped up three times, making it possible for a 1/2-horsepower motor to perform all drilling and spot-facing operations on the headstock, which include drilling a 2½-inch cored hole. It will, of course, be apparent that the radial position of the head on the arm is adjusted by means of lever *E*, and that driving rod *F* that transmits power from the spur gears to the spiral gears in case *D* is splined to provide for making this adjustment. The drill is fed to the work by hand by means of crank *G* that turns the feed-screw.

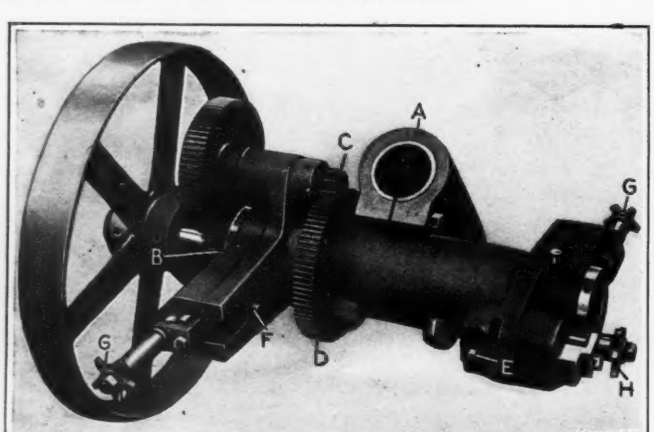

Fig. 6. Close View of Boring and Facing Equipment removed from Lathe Head to show Features of Design

Spot-facing Bosses for Feed-box and Brackets for Feed-screw and Lead-rod

After completing the drilling operations referred to, the jig plates and posts for supporting the radial arm are removed, and the radial arm is next set up on the rod extending through the spindle bearings, the radial arm being interchangeable between this rod and the posts shown in the preceding illustration. With the arm in this position, a spot-facing cutter is mounted in the spindle, and the four bosses for securing the feed-box in place and the two brackets for the feed-screw and lead-rod are spot-faced. Having completed this operation, a jig plate *A*, Fig. 8, is set up on the bar through the spindle bearings, and the holes in the bosses and brackets previously referred to are drilled and reamed. It is obviously important to have these holes properly located in relation to the ways in order that they will line up with the carriage and apron which are supported by the ways. This is done by placing a finished carriage on the ways, and slipping through the machined lead-rod bearing a master bar, the end of which extends through the lead-rod drill bushing hole in jig plate *A*.

When this has been done, the jig is properly located and it is secured in this position by tightening screws *B* at each side

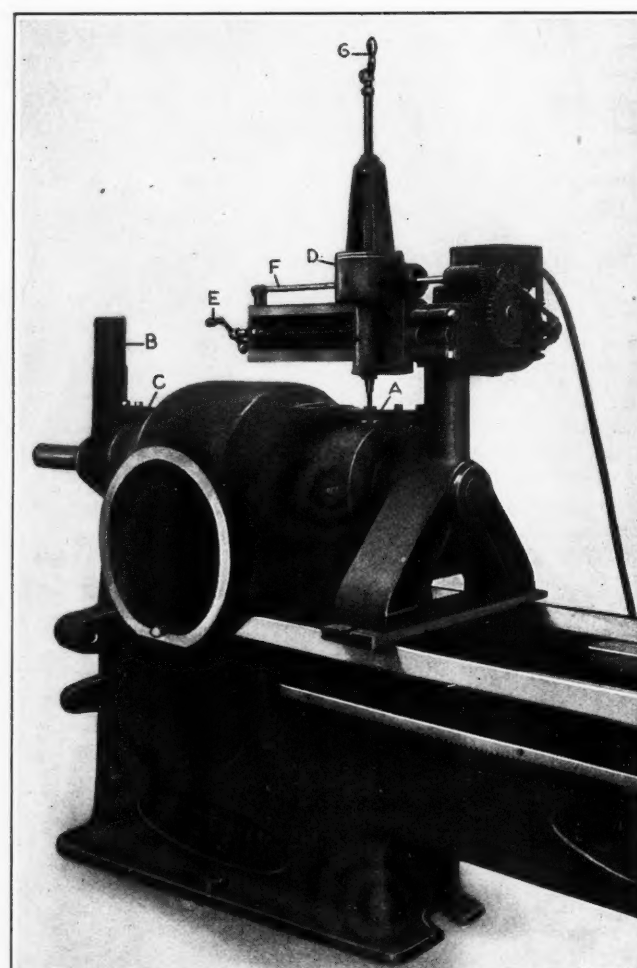

Fig. 7. Portable Radial Drilling Machine engaged in drilling Holes for Oil Cups and Wedge Clamping Screws

of the headstock. Then the master bar is withdrawn and the operator is ready to proceed with the drilling and reaming of the required holes. It will be apparent that in performing these drilling operations, location is obtained from the carefully fitted bar in the spindle bearings and from the ways on the bed and lead-rod bearing in the carriage, so that these drilling operations are conducted in a way that insures the desired alignment. The equipment for spot-facing is the same as that shown for drilling in Fig. 8, except that jig plate *A* is not necessary. This illustration shows the drilling of a 2½-inch cored hole with a tool driven by a 1/2-horsepower motor and a ½-inch splined shaft, which shows what can be done in the way of economizing power consumption if equipment is designed with that idea in view.

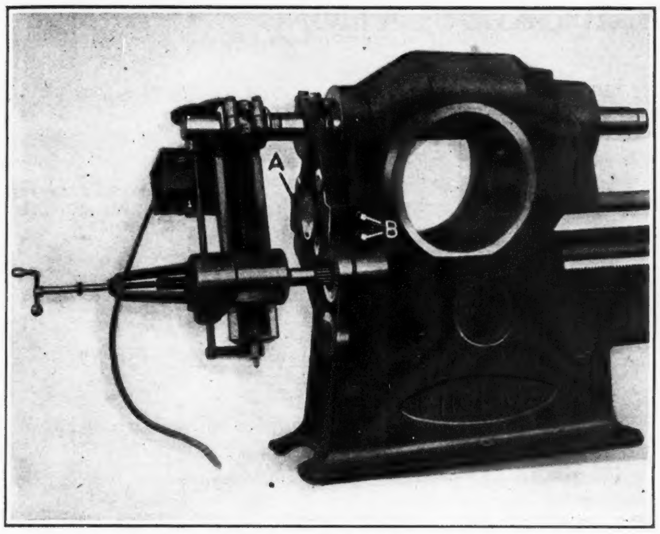

Fig. 8. Radial Drilling Machine set up for drilling Holes for Feed-screw, Lead-rod, and Screws for securing Feed-box to Bed

Drilling Operations at Tailstock End of Bed

The machining operations at the headstock end of the lathe bed have now been completed, and those operations which must be performed at the tailstock end will now be taken up. For this work, a fixture is placed on the vees, as shown in Fig. 9, and the first step is to secure to this fixture a jig plate for locating and drilling the two holes required for screws *A* that secure to the lathe bed a bracket for supporting the feed-screw and lead-rod. After this has been done, the fixture is slid along the ways, and at specified intervals screw holes are drilled to provide for securing the feed rack in place. These holes are drilled through the same jig plate used for locating and drilling the holes for screws *A*; and the points at which these holes are to be drilled are determined by having the feed rack clamped to the lathe bed, so that the holes in the casting may be drilled through the holes which have already been machined in the finished rack.

Drilling Lead-rod and Feed-screw Bracket

The final operation consists of drilling the holes in the bracket that supports the lead-rod and feed-screw; and for this purpose the jig plate is taken off the fixture shown in Fig. 9, and at the end of this fixture is substituted a jig plate for drilling the required holes in the bracket. It will be seen that this jig plate is furnished with a bushing to support a post on which is mounted the arm of the radial drill. Having set the equipment up in this way, the bracket is bolted in place on the lathe bed, and the holes are drilled in the manner shown in Fig. 10. After completing these two drilling operations, the lathe bed is ready for all parts to be assembled.

Conclusion

The way in which the location is obtained for various machining operations has been fully explained, and it will be evident to the reader who makes a careful study of conditions under which the work is done that, with reasonable care exercised by the operator, no trouble would be experienced in obtaining the desired degree of accuracy. These special tools were developed to meet the demand for equipment required for machining the beds of Conradson lathes—a demand that could not be filled by builders of standard machine tools, owing to the large amount of business standing on their books for deferred delivery. As a matter of fact, the portable tools meet all requirements, and aside from the benefit obtained through securing equipment at the time when it was required, these tools, produced at a nominal cost, are doing the work of standard machine tool equipment that would have involved the outlay of many thousands of dollars.

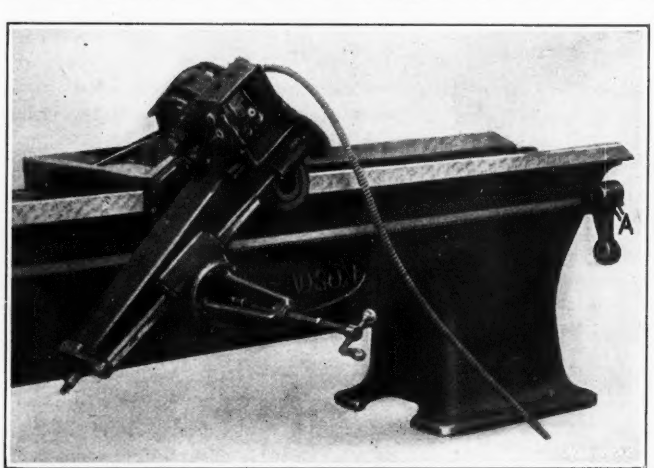

Fig. 9. Radial Drilling Machine drilling Holes for Screws used to secure Feed Rack to Bed

* * *

MAKING CUTTING TOOLS TO GAGES

BY ERIC LEE[1]

Some time ago the writer filed a number of forged cutting tools to gages. They were made of "Novo" high-speed steel and included lathe and planer tools—diamond points and round-nose cutting-off tools, right-hand and left-hand side tools and boring tools. When these tools were filed and hardened they were ground to gages made of sheet steel about 1/16 inch thick and showing the angles of rake and clearance that a series of experiments had proved were the best. Different gages were made for tools for machining tool steel, soft steel and brass. Afterward all cutting tools were milled to gage, hardened and ground by the tool-room assistant. No workman was allowed to grind his cutting tool; if the tool did not suit, it was exchanged, without comment, at the tool crib.

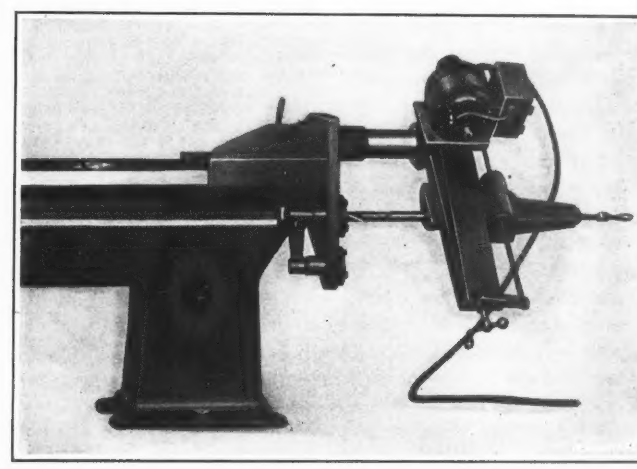

Fig. 10. Drilling Holes in Feed-screw and Lead-rod Bracket at Tailstock End of Bed

After a careful study, this method was found to be satisfactory. Men were not constantly running to the grinder to grind tools to any old angle they thought necessary. Besides, when one man was employed grinding the tools, he used goggles, whereas the other workmen would not stop to put on glasses and the number of accidents reported "foreign matter in the eyes" was greatly reduced. Although to mechanics who have been at the business many years it is often second nature to grind their tools so as to get the proper rake and clearance, many men have not had this experience, and it is a sad sight to see the grinding wheel worn away and steel wasted by some inexperienced workman trying to make a tool cut to advantage.

* * *

At a meeting of the executive committee of the National Advisory Committee for Aeronautics held in Washington, D. C., in December, the committee adopted the metric system as a standard so far as the work of the committee is concerned. Recommendations have been sent to the various departments of the government that this system be adopted in connection with all matters pertaining to aeronautics. The War Department will put the change into effect in its aviation section, using the metric and English systems on drawings.

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SIMPLIFIED CHANGE-GEAR CALCULATIONS

SOLVING CHANGE-GEAR PROBLEMS BY USE OF LOGARITHMS—LOGARITHMS OF CHANGE-GEAR RATIOS, 16 TO 120 TEETH—USING TABLE FOR FOUR-GEAR TRAINS

BY GEORGE M. MEYNCKE [1]

The calculation of change-gears is troublesome to many mechanics because the terms of the ratios are indefinite; in the case of simple ratios they may often be expressed in many pairs of tooth numbers, all within the range of an ordinary change-gear set, and it is necessary to select a suitable multiplier for one side of the ratio before the other can be known; hence the difficulty of the inexperienced in choosing gears, especially in compound trains. Change-gear problems often present serious difficulties also to those who are expert in mathematics, when the ratios cannot be exactly expressed in whole numbers within the range of ordinary gearing. The logarithmic method of finding the numbers of teeth required for a pair of change-gears in any ratio is simple and well within average comprehension. This article briefly describes the use of logarithms in change-gear calculations, and is accompanied by a table giving the logs of all the ratios from 1.0084 + : 1 to 7½ : 1, inclusive, in a gear set of 16 to 120 teeth. This table greatly simplifies the finding of pairs of change-gears, and makes the selection of gears for four-gear and six-gear sets easy.

Most shop calculations made by draftsmen, foremen or toolmakers involve the selection of gears to obtain certain ratios. When an odd thread is to be cut or it is necessary to obtain a milling-machine lead of greater accuracy than those given in the table supplied with the machine, a long and tedious calculation is usually required; and often the results are not sufficiently accurate. Numerous examples of change-gear calculations to cut unusual leads on the lathe have been given from time to time in MACHINERY, and have been kept on file by many readers because of their suggestive value. This is an indication of the general need of these data.

The slide-rule is useful in selecting gears to satisfy any ratio, but as the inaccuracy of the eye and graduations will not permit a ten-inch slide-rule to be read beyond the third figure, an unavoidable source of error is encountered; when four or six gears must be used, there is a multiplication of errors and the results become less accurate. A ten-foot slide-rule would greatly reduce this inaccuracy, but this size rule has not come into common use; few drawing-rooms possess it, and for the man in the shop it is out of the question. Also, the use of a slide-rule requires skill that comes only through frequent use.

A simple and accurate method of calculation that will enable the shop man to solve change-gear problems without a slide-rule has long been desired. Such calculations as odd threads or leads for the lathe or milling machine, change-gears for gear hobbing for the gear planer or gear shaper, and change-gears for relieving spiral-fluted hobs or cutters are among the problems most commonly encountered. The solution of these problems is the calculation of gears to obtain a certain ratio between the driving and the driven gears. An example will serve to make this clear:

Suppose that two gears must run in the ratio of 3 to 1. To find the required number of teeth in the gears, it is only necessary to multiply both terms in the ratio by the same number. As 16 is the smallest gear that can be used in most cases, multiplying both terms of the ratio by 16 gives 48 : 16. Therefore, a 48- and a 16-tooth gear may be used. Other gears that can be used are 54 : 18, obtained by multiplying both terms of the ratio 3 : 1 by 18; 60 : 20, obtained by multiplying both terms by 20; and 72 : 24, obtained by multiplying by 24. If instead of 3 to 1 the gear ratio is 3.423 to 1, the same system may be followed. A multiplier is found by trial that will give a whole, or nearly a whole number in the products; for example:

$$\begin{array}{rcl} 3.423 & : & 1 \\ 16 & & 16 \\ \hline 54.768 & : & 16 \end{array} \qquad \begin{array}{rcl} 3.423 & : & 1 \\ 18 & & 18 \\ \hline 61.614 & : & 18 \end{array} \qquad \begin{array}{rcl} 3.423 & : & 1 \\ 20 & & 20 \\ \hline 68.460 & : & 20 \end{array}$$

In each of these cases the product obtained for the 3.423 side of the ratio leaves a large fractional tooth. Taking the one with the smallest fractional tooth, 68 : 20 = 3.4 : 1, there is an error of 0.023 in the ratio.

Another and better way of obtaining the correct gears is by the cancellation method, changing 3.423 to $\frac{3423}{1000}$ to clear of decimals, and then as 3423 will not cancel small enough to obtain ordinary size gears, changing it to 3420;

$$\frac{3420}{1000}=\frac{342}{100}=\frac{3\times2\times57}{2\times50}=\frac{3\times57}{1\times50}$$

Then, multiplying $\frac{3}{1}$ by some number, say, 24, we have $\frac{72}{24}\times\frac{57}{50}=\frac{4104}{1200}=\frac{3.42}{1}$, in which there is an error of 0.003.

When the ratios are simple or when they cancel freely, the cancellation method is not difficult and is frequently used; but by the use of the logarithm method here described more accurate results are possible in most cases. The accompanying table contains the six-place logarithms of all gear combinations between 16 and 120, inclusive, excepting 1 : 1 ratios, of course; that is, all pairs of gears from 16 to 120 teeth, inclusive, are given, excepting the pairs with the same number of teeth. These logarithms were derived in the following manner: 72 : 41 equals $\frac{72}{41}$, or 72 divided by 41. To divide, find the logarithms, and subtract the logarithm of one number from the logarithm of the other, thus:

$$\begin{array}{rl} \log 72 = & 1.857333 \\ \log 41 = & 1.612784 \\ \hline \text{ratio} \log = & 0.244549 \end{array}$$

The ratio logarithms of the combinations between 16 and 120 have been arranged in numerical order in the accompanying table. In a number of cases, more than one combination gives the same logarithm, so that the different gears that equal the logarithm have been repeated. In some simple cases, however, the ratio only has been given in order to shorten the table; for instance, all the gear combinations that equal a 2 to 1 ratio have been omitted and the ratio only is given.

To show how the table is to be used, suppose that gears having the ratio 3.423 : 1 are desired. Log 3.423 = 0.534407. From the table, log 89 : 26 = 0.534417; therefore, the gears having 89 and 26 teeth are the nearest to the ratio 3.423 to 1, and as 89 ÷ 26 = 3.423077, the ratio error is only 0.000077. The error by the cancellation method, using four gears, was 0.003. This can be reduced after a number of changes have been made in the ratio 3423 : 1000. However, there is no way of determining if the error has been reduced to the lowest possible figure; but with the gear ratio logarithms this can be discovered at once by an inspection of the table.

There are nearly 5000 different ratios represented in the gear tables between the extremes 1.0084 + to 1 (120 : 119) and 7½ to 1 (120 to 16). As the sum of any two two-gear logarithms equals a four-gear logarithm, the tables represent over 12,000,000 four-gear combinations; and by using three pairs of gears in a train, there are over 20,000,000,000 six-gear combinations available.

When solving gear problems the ratio always should be reduced to terms of 1. For example, what two gears will drive two shafts at a ratio of 7.182 to 3.902? $\frac{7.182}{3.902}=\frac{1.84059}{1}$; the log of 1.84059 is 0.264957. From the table, 81 : 44 = log 0.265032. As 81 ÷ 44 = 1.84091, the table error is only 0.00032. The advantage of reducing to terms of 1 is that it checks all work, including the taking out of the logarithms.

Caution—Extraordinary care has been taken to eliminate errors in the accompanying table of change-gear logarithms, but the difficulty of securing perfect accuracy in the first presentation of a table containing nearly 5000 items is enormous, and it is too much to expect that there are no mistakes. Users are cautioned, therefore, to check all data taken for their computations, by finding the logs of each pair of tooth numbers in a six-place table, and subtracting one from the other; the remainder is the log of the ratio, and should agree with that given in the accompanying table, if both are correct.—EDITOR.

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A more rapid solution of the same problem, which may be used by those familiar with logarithms, is:

$$\log 7.182 = 0.856245$$
$$\log 3.902 = 0.591287$$
$$\text{ratio log} = 0.264958$$

From the table, log 81 : 44 = 0.265032. To find the error, proceed thus:

$$\log 0.265032$$
$$\log 0.264958$$
$$\text{log of ratio error } 0.000074$$

Finding Four-gear Ratios

When four gears must be used, the gear logarithms permit of more accurate results being obtained than any other method. For example, suppose it is desired to find four gears that will yield a ratio of 2.105399 to 1. Log 2.105399 = 0.323334. To keep the reduction about equal in each pair of gears, it is necessary to select from the table that set of gears the logarithm of which is equal to about one-half the ratio logarithm, as log 57 : 37 = 0.187673. By subtracting this from log 0.323334, the other logarithm is found to be 0.135661. From

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH—1

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
120:16	0.875061	118:21	.749663	89:18	0.694118	103:23	.651109	99:24	0.615424	107:28	.582226	111:31	0.553961	91:27	.527678
119:16	.871427	101:18	.749049	84:17	.693830	94:21	.650909	66:16	.615424	84:22	.581857	68:19	.553755	64:19	.527426
118:16	.867762	112:20	.748188	79:16	.693507	85:19	.650665	103:25	.614897	103:27	.581473	93:26	.553504	101:30	.527200
117:16	.864065	95:17	.747275	118:24	.691671	76:17	.650365	70:17	.614649	61:16	.581210	118:33	.553368	111:33	.526809
116:16	.860338	106:19	.746552	113:23	.691351	116:26	.649485	107:26	.614411	80:21	.580871	100:28	.552842	74:22	.526809
115:16	.856578	117:21	0.745967	108:22	.691001	107:24	0.649173	111:27	.613959	99:26	0.580662	75:21	.552842	84:25	0.526339
114:16	.852785	89:16	.745270	103:21	.690618	98:22	.648803	74:18	.613959	118:31	.580520	107:30	.552263	94:28	.525970
113:16	.848958	100:18	.744728	98:20	.690196	89:20	.648360	115:28	.613540	114:30	.579784	82:23	.552086	104:31	.525672
120:17	.848732	111:20	.744293	93:19	.689729	80:18	.647818	78:19	.613341	95:25	.579784	114:32	.551755	114:34	.525426
119:17	.845098	94:17	.742680	88:18	.689210	120:27	.647817	119:29	.613149	76:20	.579784	89:25	.551450	67:20	.525045
112:16	0.845098	105:19	.742436	83:17	0.688629	111:25	.647383	82:20	0.612784	110:29	.578995	96:27	0.550907	77:23	.524763
118:17	.841433	116:21	.742239	117:24	.687975	71:16	.647138	86:21	.612279	91:24	.578830	64:18	.550907	87:26	.524546
111:16	.841203	110:20	.740363	78:16	.687975	102:23	.646872	90:22	.611820	72:19	.578579	103:29	.550439	97:29	.524374
117:17	.837737	99:18	.740363	112:23	.687490	93:21	.646264	94:23	.611400	106:28	.578148	71:20	.550228	107:32	.524234
110:16	.837272	88:16	.740363	107:22	.686961	115:26	.645725	98:24	.611015	87:23	.577792	110:31	.550031	117:35	.524118
116:17	.834009	115:21	0.738479	102:21	.686381	84:19	0.645526	102:25	.610660	102:27	0.577236	117:33	.549672	120:36	0.522879
109:16	.833307	104:19	.738280	97:20	.685742	106:24	.645095	106:26	.610333	68:18	.577236	78:22	.549672	110:33	.522879
115:17	.830249	93:17	.738034	92:19	.685034	75:17	.644612	110:27	.610029	117:31	.576824	85:24	.549208	100:30	.522879
108:16	.829304	120:22	.736759	116:24	.684247	97:22	.644349	114:28	.609747	83:22	.576655	92:26	.548815	90:27	.522879
114:17	.826456	109:20	.736397	87:18	.684247	119:27	.644183	112:29	.609484	98:26	.576253	99:28	.548477	80:24	.522879
107:16	0.825264	98:18	.735954	111:23	0.683595	110:25	.643453	65:16	0.608793	113:30	.575957	106:30	0.548185	70:21	.522879
120:18	.823909	87:16	.735400	82:17	.683365	88:20	.643453	69:17	.608400	64:17	.575731	113:32	.547928	60:18	.522879
113:17	.822629	114:21	.734686	106:22	.682883	101:23	.642594	73:18	.608050	79:21	.575408	120:34	.547702	113:34	.521600
106:16	.821186	103:19	.734084	77:16	.682371	79:18	.642355	77:19	.607737	94:25	.575188	67:19	.547321	103:31	.521476
119:18	.820275	92:17	.733339	101:21	.682102	114:26	.641932	81:20	.607455	109:29	.575029	74:21	.547012	93:28	.521325
112:17	.818769	119:22	0.733124	120:25	.681241	92:21	0.641569	85:21	.607200	120:32	0.574031	81:23	.546757	83:25	0.521138
105:16	.817069	108:20	.732394	96:20	.681241	105:24	.640978	89:22	.606967	105:28	.574031	88:25	.546543	73:22	.520900
118:18	.816609	97:18	.731499	115:24	.680487	70:16	.640978	93:23	.606755	90:24	.574031	95:27	.546360	63:19	.520587
111:17	.814874	113:21	.730859	91:19	.680288	118:27	.640518	97:24	.606561	75:20	.574031	102:29	.546202	116:35	.520390
117:18	.812913	86:16	.730379	110:23	.679665	83:19	.640324	101:25	.606381	60:16	.574031	109:31	.546065	106:32	.520156
104:16	0.812913	102:19	.729847	86:18	0.679226	96:22	.639849	105:26	0.606216	116:31	.573096	119:34	0.544068	96:29	.519873
110:17	.810944	118:22	.729459	105:22	.678767	109:25	.639487	109:27	.606063	86:23	.572770	112:32	.544068	86:26	.519525
116:18	.809186	91:17	.728593	81:17	.678036	74:17	.638783	113:28	.605920	71:19	.572505	105:30	.544068	119:36	.519245
103:16	.808717	107:20	.728354	100:21	.677781	87:20	.638489	117:29	.605788	112:30	.572097	98:28	.544068	76:23	.519086
109:17	.806978	112:21	.726999	119:25	.677607	100:23	.638272	116:23	.602730	97:26	.571798	91:26	.544068	109:33	.518913
115:18	.805425	96:18	0.726999	114:24	.676694	113:26	0.638105	64:16		82:22	0.571391	84:24	.544068	99:30	0.518514
102:16	.804480	117:22	.725763	95:20	.676694	117:27	.636822	or		108:29	.571026	77:22	.544068	89:27	.518026
108:17	.802975	101:19	.725568	76:16	.676694	104:24	.636822	any	.602060	67.18	.570802	70:20	.544068	112:34	.517739
114:18	.801632	85:16	.725299	109:23	.675699	91:21	.636822	4 to 1		93:25	.570543	63:18	.544068	79:24	.517416
120:19	.800428	106:20	.724276	90:19	.675489	78:18	.636822	ratio		119:32	.570397	56:16	.544068	102:31	.517239
101:16	0.800201	90:17	.723794	104:22	0.674611	108:25	.635484	119:30	0.598426	104:28	.569875	115:33	0.542184	115:35	.516630
107:17	.798936	111:21	.723104	85:18	.674146	95:22	.635301	115:29	.598300	78:21	.569875	108:31	.542062	69:21	.516630
113:18	.797806	95:18	.722451	118:25	.673942	82:19	.635060	111:28	.598165	115:31	.569336	101:29	.541923	92:28	.516629
119:19	.796793	116:22	.722035	99:21	.673416	69:16	.634729	107:27	.598020	89:24	.569179	87:25	.541579	105:32	.516039
100:16	.795880	100:19	.721246	113:24	.672867	112:26	.634245	103:26	.597864	63:17	.568892	80:23	.541362	82:25	.515874
106:17	.794857	105:20	0.720159	80:17	.672641	99:23	0.633907	99:25	.597695	100:27	0.568636	73:21	.541104	118:36	0.515580
112:18	.793946	84:16	.720159	94:20	.672098	86:20	.633469	95:24	.597512	111:30	.568202	66:19	.540790	95:29	.515326
118:19	.793128	110:21	.719173	108:23	.671696	116:27	.633094	91:23	.597314	74:20	.568202	118:34	.540403	108:33	.514910
99:16	.791515	89:17	.718941	75:16	.670941	73:17	.632874	87:22	.597097	85:23	.567691	111:32	.540173	77:22	.514910
105:17	.790740	115:22	.718275	89:19	.670636	103:24	.632626	83:21	.596859	96:26	.567298	104:30	.539912	85:26	.514446
111:18	0.790051	94:18	.717855	103:22	0.670415	120:28	.632023	79:20	0.596597	107:29	.566986	97:28	0.539614	98:30	.514105
98:16	.787106	120:23	.717453	117:25	.670246	90:21	.632023	75:19	.596308	118:32	.566732	90:26	.539269	111:34	.513844
104:17	.786584	99:19	.716882	112:24	.669007	107:25	.631444	71:18	.595986	70:19	.566344	83:24	.538867	62:19	.513638
110:18	.786120	109:21	.715207	98:21	.669007	77:18	.631218	67:17	.595626	81:22	.566062	114:33	.538391	75:23	.513334
116:19	.785704	83:16	.714958	84:18	.669007	94:22	.630705	63:16	.595221	92:25	.565848	76:22	.538391	88:27	.513119
97:16	.782652	114:22	0.714482	107:23	.667656	111:26	0.630350	118:30	.594761	103:28	0.565679	107:31	.538022	101:31	0.512960
103:17	.782388	88:17	.714034	93:20	.667453	81:19	.629731	114:29	.594507	114:31	.565543	69:20	.537819	114:35	.512837
109:18	.782154	119:23	.713819	79:17	.667178	98:23	.629498	110:28	.594235	88:24	.564272	100:29	.537602	117:36	.511883
115:19	.781944	93:18	.713210	116:25	.666518	115:27	.629334	106:27	.593942	110:30	.564271	93:27	.537119	104:32	.511883
114:19	.778151	98:19	.712473	102:22	.666178	119:28	.628389	102:26	.593627	99:27	.564271	62:18	.537119	91:28	.511883
108:18	0.778151	103:20	.711807	88:19	0.665730	85:20	.628389	98:25	0.593286	77:21	.564271	117:34	0.536707	65:20	.511883
102:17	.778151	108:21	.711205	111:24	.665112	68:16	.628389	94:24	.592917	66:18	.564271	86:25	.536559	120:37	.510980
96:16	.778151	113:22	.710656	74:16	.665112	106:25	.627366	90:23	.592515	117:32	.563036	110:32	.536243	107:33	.510870
119:20	.774517	118:23	.710154	97:21	.664552	89:21	.627171	86:22	.592076	106:29	.562908	55:16	.536243	94:29	.510730
113:19	.774325	82:16	.709694	120:26	.664208	72:17	.626884	82:21	.591595	73:20	.562293	79:23	.535899	81:25	.510545
107:18	.774111	87:17	0.709070	83:18	.663806	110:26	0.626419	117:30	.591065	95:26	0.562750	103:30	.535716	68:21	0.510290
101:17	.773873	92:18	.708515	106:23	.663578	93:22	.626060	78:20	.591065	84:23	.562552	120:35	.535113	110:34	.509914
95:16	.773604	97:19	.708018	115:25	.662758	114:27	.625541	113:29	.590680	62:17	.561943	96:28	.535113	97:30	.509650
112:19	.770464	102:20	.707570	92:20	.662758	76:18	.625541	74:19	.590478	113:31	.561717	72:21	.535113	84:26	.509306
106:18	.770033	107:21	.707165	101:22	.661899	97:23	.625044	109:28	.590269	102:28	.561442	113:33	.534565	113:35	.509010
100:17	0.769551	112:22	.706795	78:17	0.661645	118:28	.624724	105:27	0.589826	91:25	.561101	89:26	0.534417	71:22	.508836
94:16	.769008	117:23	.706458	110:24	.661182	80:19	.624336	70:18	.589826	120:33	.560667	65:19	.534160	100:31	.508638
117:20	.767156	81:16	.704365	87:19	.660766	101:24	.624110	101:26	.589348	80:22	.560667	106:31	.533944	116:36	.508156
111:19	.766570	86:17	.704050	119:26	.660574	105:25	.623249	66:17	.589105	109:30	.560305	82:24	.533603	87:27	.508156
105:18	.765917	91:18	.703769	96:21	.660052	84:20	.623249	97:25	.588832	69:19	.560096	99:29	.533237	103:32	.507687
99:17	.765186	96:19	0.703518	105:23	.659462	109:26	0.622453	62:16	.588272	98:27	0.559862	116:34	.532980	74:23	0.507504
93:16	.764363	101:20	.703291	73:16	.659203	88:21	.622263	120:31	.587820	116:32	.559308	75:22	.532639	119:37	.507345
116:20	.763429	106:21	.703087	114:25	.658965	67:16	.621955	89:23	.587662	87:24	.559308	92:27	.532424	90:28	.507085
110:19	.762639	111:22	.702900	82:18	.658541	113:27	.621715	116:30	.587337	105:29	.558791	109:32	.532277	106:33	.506792
104:18	.761761	116:23	.702730	91:20	.658011	92:22	.621365	85:22	.586996	76:21	.558594	119:35	.531479	61:19	.506576
98:17	0.760777	120:24	.698970	100:22	0.657577	117:28	.621028	112:29	0.586820	94:26	.558155	102:30	0.531479	77:24	.506280
115:20	.759668	115:23	.698970	109:24	.657215	71:17	.620809	108:28	.586266	112:31	.557856	85:25	.531479	93:29	.506085
92:16	.759668	110:22	.698970	118:26	.656909	96:23	.620543	81:21	.586266	65:18	.557641	68:20	.531479	109:34	.505948
109:19	.758673	105:21	.698970	77:17	.656042	100:24	.619789	104:27	.585670	83:23	.557350	112:33	.530704	112:35	.505150
103:18	.757565	100:20	.698970	86:19	.655745	75:18	.619789	77:20	.585461	101:28	.557163	95:28	.530566	96:30	.505150
120:21	.756962	95:19	0.698970	95:21	.655504	104:25	0.619093	100:26	.585027	119:33	0.557033	78:23	.530367	80:25	0.505150
114:20	.755875	90:18	.698970	104:23	.655306	79:19	.618874	73:19	.584569	108:30	.556303	61:18	.530057	64:20	.505150
91:16	.754921	85:17	.698970	113:25	.655138	108:26	.618451	96:25	.584331	90:25	.556303	105:31	.529828	115:36	.504395
108:19	.754670	80:16	.698970	117:26	.653213	83:20	.618048	119:31	.584185	72:20	.556303	88:26	.529509	99:31	.504274
119:21	.753328	119:24	.695336	108:24	.653213	112:27	.617854	115:30	.583577	115:32	.555548	115:34	.529219	83:26	.504105
102:18	0.753328	114:23	.695171	99:22	0.653213	116:28	.617300	92:24	0.583577	97:27	.555408	71:21	0.529039	67:21	.503856
113:20	.752048	109:22	.695004	90:20	.653213	87:21	.617300	69:18	.583577	79:22	.555204	98:29	.528828	118:37	.503680
96:17	.751822	104:21	.694814	81:18	.653213	120:29	.616783	111:29	.582925	61:17	.554881	108:32	.528274	102.32	.503450
107:19	.750630	99:20	.694605	72:16	.653213	91:22	.616619	88:23	.582755	104:29	.554635	81:24	.528274	86:27	.503135
90:16	.750123	94:19	.694374	112:25	.651278	95:23	.615996	65:17	.582465	86:24	.554287	118:35	.527814	105:33	.502675

Machinery

the table, log 41 : 30 = 0.135663, so the error is log 0.000002. Thus this result is obtained:

$$\frac{57}{37} \times \frac{41}{30} = \frac{2337}{1110} = 2.105405$$

As the ratio of the gears is 2.105405 and the desired ratio is 2.105399, the error in the ratio is 0.000006. It should be noted that in this case the gearing does not overlap; that is, the two largest gears will be drivers or driven, whichever the case may be.

In case no combination can be found that nearly equals the logarithm of the ratio, a suitable four-gear combination may be found by reversing the second ratio selected from the table. For example, what gears will drive two shafts at a ratio of 595 to 594? Taking the logs from a six-place table, we have:

$$\log 595 = 2.774517$$
$$\log 594 = 2.773786$$
$$\log \text{ratio} = 0.000731$$

From the accompanying table select any ratio, say log 72 : 70 = 0.012235, and add the logarithm of the ratio 595 : 594,

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH—2

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
70:22	0.502675	119:40	.473487	119:42	.452298	100:37	.431798	111:43	.411855	96:39	.391207	90:38	.374459	107:47	.357286
89:28	.502232	116:39	.473393	102:36	0.452298	108:40	.431364	80:31	.411728	64:26	.391207	116:49	.374262	66:29	0.357146
108:34	.501945	113:38	.473295	85:30	.452298	81:30	.431364	98:38	.411443	91:37	.390840	71:30	.374137	91:40	.356981
73:23	.501595	110:37	.473191	68:24	.452298	54:20	.431364	67:26	0.411102	59:24	.390641	97:41	.373988	116:51	.356888
92:29	.501390	107:36	.473081	116:41	.451674	116:43	.430990	116:45	.411246	86:35	.390431	78:33	.373581	75:33	.356547
111:35	.501255	104:35	0.472965	99:35	.451567	89:33	.430876	85:33	.410905	113:46	.390321	52:22	0.373581	50:22	.356547
95:30	.500602	101:34	.472843	82:29	.451416	62:23	.430664	103:40	.410777	108:44	.389971	111:47	.373225	100:44	.356547
76:24	.500602	98:33	.472712	65:23	.451186	97:36	0.430469	90:35	.410175	81:33	.389971	85:36	.373116	109:48	.356185
117:37	.499984	95:32	.472574	113:40	.451018	105:39	.430125	72:28	.410175	54:22	.389971	59:25	.372912	84:37	.356078
98:31	.499864	92:31	.472426	96:34	.450792	70:26	.430125	54:21	.410175	103:42	0.389588	92:39	.372723	59:26	.355879
79:25	0.499687	89:30	.472269	79:28	.450469	113:42	.429829	113:44	.409626	76:31	.389452	66:28	.372386	93:41	.355699
120:38	.499398	86:29	.472101	110:39	0.450328	78:29	.429697	95:37	.409522	98:40	.389166	99:42	.372386	102:45	0.355388
101:32	.499171	83:28	.471920	93:33	.449969	86:32	.429349	77:30	.409369	49:20	.389166	106:45	.372093	68:30	.355388
82:26	.498841	80:27	.471726	62:22	.449970	94:35	.429060	59:23	0.409124	120:49	.388985	73:31	.371961	111:49	.355127
104:33	.498519	77:26	.471517	107:38	.449600	102:38	.428817	100:39	.408935	71:29	.388860	113:48	.371837	77:34	.355012
63:20	.498311	74:25	0.471291	76:27	.449450	110:41	.428609	82:32	.408664	93:38	.388699	120:51	0.371611	120:53	.354905
85:27	.498055	71:24	.471047	90:32	.449092	59:22	.428429	105:41	.408405	115:47	.388600	80:34	.371611	86:38	.354715
107:34	.497905	68:23	.470781	104:37	.448832	67:25	0.428135	64:25	.408240	110:45	.388180	87:37	.371318	95:42	.354474
110:35	.497325	65:22	.470491	118:42	.448633	75:28	.427903	87:34	.408040	88:36	.388180	94:40	.371068	52:23	.354276
88:28	.497325	62:21	.470172	73:26	.448350	83:31	.427716	110:43	.407924	66:27	0.388180	47:20	.371068	113:50	.354108
113:36	0.496776	118:40	.469822	87:31	.448158	91:34	.427563	115:45	.407485	105:43	.387721	101:43	.370853	61:27	.353966
91:29	.496643	115:39	.469633	101:36	0.448019	99:37	.427434	92:36	.407485	83:34	.387599	54:23	.370666	70:31	0.353736
69:22	.496426	112:38	.469434	115:41	.447914	107:40	.427324	69:27	.407485	61:25	.387390	115:49	.370502	79:35	.353559
116:37	.496256	109:37	.469225	98:35	.447158	115:43	.427229	120:47	0.407083	100:41	.387216	61:26	.370357	88:39	.353418
94:30	.496007	106:36	.469003	84:30	.447158	120:45	.425969	97:38	.406988	117:48	.386945	68:29	.370111	97:43	.353303
119:38	.495763	103:35	0.468769	112:40	.447159	112:42	.425969	74:29	.406834	78:32	.386945	75:32	0.369911	106:47	.353208
72:23	.495605	100:34	.468521	70:25	.447159	104:39	.425969	51:20	.406540	95:39	.386659	82:35	.369746	115:51	.353128
97:31	.495410	97:33	.468258	109:39	.446362	96:36	0.425969	79:31	.406265	112:46	.386460	89:38	.369606	117:52	.352183
100:32	.494850	94:32	.467978	95:34	.446245	88:33	.425969	107:42	.406135	56:23	.386460	96:41	.369487	108:48	.352183
75:24	.494850	91:31	.467680	81:29	.446087	80:30	.425969	84:33	.405765	73:30	0.386202	103:44	.369385	99:44	.352183
103:33	0.494323	88:30	.467361	67:24	.445864	72:27	.425969	56:22	.405765	90:37	.386041	110:47	.369295	90:40	.352183
78:25	.494155	85:29	.467021	120:43	0.445713	64:24	.425969	117:46	.405428	107:44	.385931	117:50	.369216	81:36	0.352183
106:34	.493827	82:28	.466656	106:38	.445522	56:21	.425969	89:35	.405322	102:42	.385351	119:51	.367977	72:32	.352183
81:26	.493511	120:41	.466397	92:33	.445274	117:44	.424733	61:24	0.405119	119:49	.385351	105:45	.367977	63:28	.352183
109:35	.493359	79:27	.466263	117:42	.444937	109:41	.424643	94:37	.404926	85:35	.385351	98:42	.367977	45:20	.352183
112:36	.492916	117:40	0.466126	78:28	.444937	101:38	.424538	99:39	.404571	68:28	.385351	91:39	0.367977	119:53	.351271
84:27	.492916	114:39	.465840	103:37	.444636	93:35	.424415	66:26	.404571	51:21	.385351	84:36	.367977	110:49	.351197
115:37	.492496	76:26	.465840	64:23	.444452	85:32	0.424269	104:41	.404249	114:47	.384807	77:33	.367977	101:45	.251109
87:28	.492361	111:38	.465539	89:32	.444240	77:29	.424093	71:28	.404100	97:40	.384712	70:30	.367977	92:41	.351004
118:38	.492098	73:25	.465383	114:41	.444121	69:26	.423876	109:43	.403958	80:33	0.384576	63:27	.367977	83:37	.350876
90:29	0.491845	108:37	.465222	100:36	.443698	61:23	.423602	114:45	.403692	63:26	.384367	56:24	.367977	74:33	.350718
93:30	.491362	70:24	.464887	75:27	0.443698	114:43	.423436	76:30	.403692	109:45	.384214	49:21	.367977	65:29	0.350515
62:20	.491362	102:35	.464532	111:40	.443263	106:40	.423246	119:47	.403449	92:38	.384004	114:49	.366709	56:25	.350248
96:31	.490910	67:23	.464347	86:31	.443137	98:37	.423024	81:32	0.403335	75:31	.383700	107:46	.366626	103:46	.350079
65:21	.490694	99:34	.464156	61:22	.442907	90:34	.422764	86:34	.403020	104:43	.383565	100:43	.366532	94:42	.349879
99:32	.490485	96:33	0.463757	97:35	.442704	82:31	.422452	91:36	.402739	87:36	.383217	93:40	0.366423	85:38	.349635
102:33	.490086	64:22	.463757	72:26	.442359	119:45	.422335	96:38	.402488	58:24	.383217	86:37	.366297	114:51	.349335
68:22	.490086	93:32	.463333	108:39	.442360	111:42	0.422074	101:40	.402261	99:41	.382851	79:34	.366148	76:34	.349335
105:34	.489710	90:31	.462881	119:43	.442079	74:28	.422074	53:21	.402057	70:29	.382700	72:31	.365971	105:47	.349091
71:23	.489531	61:21	.463111	83:30	.441957	103:39	.421773	111:44	.401870	111:46	0.382565	65:28	.365755	67:30	.348954
108:35	0.489356	119:41	.462763	94:34	.441649	95:36	.421421	58:23	.401700	82:34	.382335	58:25	.365488	96:43	.348803
111:36	.489021	116:40	.462398	105:38	0.441406	87:33	.421005	63:25	.401401	94:39	.382063	109:47	.365329	87:39	0.348455
74:24	.489021	87:30	.462398	58:21	.441209	58:22	.421005	68:27	.401145	53:22	.381853	102:44	.365148	58:26	.348455
114:37	.488703	58:20	.462398	80:29	.440692	108:41	.420640	73:29	0.400925	118:49	.381686	95:41	.364940	107:48	.348143
77:25	.488551	84:29	.461881	91:33	.440528	79:30	.420506	78:31	.400733	65:27	.381550	88:38	.364700	78:35	.348027
117:38	.488402	110:38	0.461609	102:37	.440399	100:38	.420216	83:33	.400564	77:32	.381341	81:35	0.364417	98:44	.347773
120:39	.488117	81:28	.461327	113:41	.440295	71:27	.419895	88:35	.400415	89:37	.381188	118:51	.364312	49:22	.347773
80:26	.488117	107:37	.461182	110:40	.439333	92:35	0.419720	93:37	.400281	101:42	.381072	111:48	.364083	118:53	.347606
83:27	.487714	69:25	.460909	99:36	.439333	113:43	.419610	98:39	.400162	113:47	.380981	74:32	.364082	69:31	.347487
86:28	.487341	104:36	.460731	88:32	.439333	105:40	.419130	103:41	.400053	120:50	0.380211	104:45	.363821	89:40	.347330
89:29	0.486992	78:27	.460731	77:28	.439333	63:24	.419130	108:43	.399955	108:45	.380211	67:29	.363677	109:49	.347230
92:30	.486667	101:35	.460253	118:43	0.438414	84:32	.419129	113:45	.399866	96:40	.380211	90:39	.363178	100:45	0.346788
95:31	.486362	75:26	.460088	107:39	.438319	118:45	.418670	118:47	.399784	84:35	.380211	60:26	.363178	80:36	.346788
98:32	.486076	98:34	.459747	96:35	.438203	97:37	.418570	40:16		72:30	.380211	113:49	.362882	60:27	.346788
101:33	.485808	72:25	.459393	85:31	.438057	76:29	.418416	or any	0.397940	60:25	.380211	53:23	.362548	111:50	.346353
104:34	.485554	95:33	0.459210	74:27	.437868	55:21	.418143	2½ to 1		48:20	.380211	76:33	0.362300	91:41	.346258
107:35	.485316	118:41	.459098	63:23	.437613	89:34	.417911	ratio		115:48	.379457	99:43	.362167	51:23	.345842
110:36	.485090	115:40	.458638	115:42	.437449	102:39	0.417536	117:47	.396088	103:43	.379369	115:50	.361728	113:51	.345508
113:37	.484877	92:32	.458638	104:38	.437250	68:26	.417536	112:45	.396006	91:38	.379258	92:40	.361728	93:42	.345234
116:38	.484674	69:24	.458638	93:34	.437004	115:44	.417245	107:43	.395915	79:33	0.379113	69:30	.361728	62:28	.345234
119:39	0.484482	112:39	.458153	82:30	.436693	81:31	.417123	102:41	.395816	67:28	.378916	46:20	.361728	104:47	.344935
61:20	.484300	89:31	.458028	112:41	0.436434	94:36	.416825	97:39	.395707	55:23	.378635	108:47	.361326	73:33	0.344809
64:21	.483961	66:23	.457816	71:26	.436285	107:41	.416600	92:37	.395586	98:41	.378442	85:37	.361217	115:52	.344695
67:22	.483652	109:38	.457643	101:37	.436120	60:23	.416424	87:35	0.395451	86:36	.378196	62:27	.361028	84:38	.344496
70:23	.483370	86:30	.457377	90:33	.435729	73:28	.416165	82:33	.395300	117:49	.377990	101:44	.360869	95:43	.344255
73:24	.483112	106:37	0.457104	60:22	.435729	86:33	.415985	77:31	.395129	74:31	.377870	117:51	0.360616	53:24	.344065
76:25	.482874	63:22	.456918	109:40	.435367	99:38	.415852	72:29	.394935	105:44	.377737	78:34	.360616	117:53	.343910
79:26	.482654	83:29	.456680	79:29	.435229	112:43	0.415750	67:27	.394711	93:39	.377418	94:41	.360344	64:29	.343782
82:27	.482450	103:36	.456535	98:36	.434924	117:45	.414973	62:25	.394452	62:26	.377418	55:24	.360152	75:34	.343582
85:28	.482261	120:42	.455932	117:43	.434717	91:35	.414973	119:48	.394306	112:47	0.377120	71:31	.359897	86:39	.343434
88:29	0.482085	100:35	.455932	68:25	.434569	78:30	.414973	57:23	.394147	81:34	.377006	.87:38	.359736	97:44	.343319
91:30	.481920	80:28	.455932	87:32	0.434369	52:20	.414973	109:44	.393974	100:42	.376751	103:45	.359625	108:49	0.343228
94:31	.481756	60:21	.455932	106:39	.434241	109:42	.414177	52:21	.393784	50:21	.376751	119:52	.359544	119:54	.343153
97:32	.481622	117:41	.455402	114:42	.433656	96:37	.414070	99:40	0.393575	119:50	.376577	112:49	.359022	99:45	.342423
100:33	.481486	97:34	.455293	95:35	.433656	83:32	.413928	94:38	.393344	69:29	.376451	96:42	.359022	88:40	.342423
103:34	.481358	77:27	0.455127	76:28	.433656	70:27	.413734	89:36	.393088	88:37	.376281	80:35	0.359022	77:35	.342423
106:35	.481237	114:40	.454845	57:21	.433656	57:22	.413452	84:34	.392800	107:45	.376171	64:28	.359022	66:30	.342423
109:36	.481124	94:33	.454614	103:38	.433054	101:39	0.413257	79:32	.392477	95:40	.375664	48:21	.359022	55:25	.342423
112:37	.481016	111:39	.454258	84:31	.432918	88:34	.413004	116:47	.392360	76:32	.375664	105:46	.358432	112:51	.341648
115:38	.480914	74:26	.454258	65:24	.432702	119:46	.412789	111:45	.392111	57:24	0.375664	89:39	.358325	101:46	.341564
118:39	0.480817	91:32	.453891	111:41	.432539	75:29	.412663	74:30	.392116	102:43	.375132	73:32	.358173	90:41	.341459
48:16		71:25	.453318	92:34	0.432309	106:41	.412522	106:43	.391837	83:35	.375010	57:25	.357935	79:36	0.341325
or any	.477121	88:31	.453121	119:44	.432094	62:24	.412181	69:28	.391691	64:27	.374816	98:43	.357758	57:26	.340902
3 to 1		105:37	.452988	73:27	.431959	93:36	.412180	101:41	0.391538	109:46	.374669	82:36	.357511	103:47	.340739
ratio															

Machinery

or 0.000731; the sum is 0.012966. Select the logarithm nearest the sum from the table; this is found to be log 68 : 66 = 0.012965. Now by reversing this pair the difference of the ratios, or 594 : 595, will be obtained. Reversing 68 : 66 gives 66 : 68; therefore, the gears required are $\frac{72}{70} \times \frac{66}{68}$. The proof of this is: $\frac{72}{70} \times \frac{66}{68} = \frac{4752}{4760} = \frac{594}{595}$.

It is evident that overlapping is necessary only when the ratio is nearly 1 to 1. Care should be taken in overlapping to avoid interference on the machine. The best rule is to keep the gears as near the same size as possible.

Driver and Driven Gears

Gears for the ratio 7.32 : 4.17 are selected in the same manner as gears for the ratio 4.17 : 7.32. The logarithm of the smaller number is subtracted from the logarithm of the larger, giving the logarithm of the ratio. There may be some difficulty in determining which gears are the drivers and which the driven. The first figure of a gear ratio is usually considered to be the driver. For example, if two shafts are to

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH–3

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
92:42	.340539	74:35	.325164	92:45	.0310575	96:49	.292075	89:47	.277292	77:42	.263241	80:45	.249878	76:44	0.237361
46:21	.340539	93:44	.325030	94:46	.310370	94:48	.291887	53:28	.277118	66:36	.263241	64:36	.249878	57:33	.237361
81:37	.340283	112.53	.324942	96:47	.310173	92:47	.291690	87:46	0.276762	55:30	.263241	119:67	.249472	38:22	.237361
116:53	.340182	95:45	0.324511	98:48	.309985	90:46	.291485	104:55	.276671	119:65	.262634	103:58	.249409	107:62	.236992
105:48	.339948	76:36	.324511	100:49	.309804	88:45	.291270	119:63	.276207	108:59	.262572	87:49	0.249323	88:51	.236913
70:32	.339948	57:27	.324511	102:50	.309630	86:44	.291046	85:45	.276207	97:53	.262496	71:40	.249198	69:40	.236789
93:43	.339659	116:55	.324095	51:25	.309630	84:43	0.290811	68:36	.276206	86:47	.262401	110:62	.249001	119:69	.236698
118:54	0.339488	97:46	.324014	104:51	.309463	82:42	.290565	117:62	.275794	75:41	.262277	55:31	.249001	100:58	.236572
59:27	.339488	78:37	.323893	53:26	.309303	41:21	.290565	100:53	.275724	64:35	0.262112	94:53	.248852	50:29	.236572
83:38	.339295	59:28	.323694	108:53	.309148	80:41	.290306	83:44	.275625	53:29	.261878	117:66	.248642	81:47	.236387
107:49	.339188	99:47	.323537	55:27	0.308999	119.61	.290217	66:35	.275476	95:52	.261720	78:44	.248642	112:65	0.236305
120:55	.338819	120:57	.323306	112:55	.308855	78:40	.290035	115:61	.275368	84:46	.261522	101:57	.248447	62:36	.236089
96:44	.338819	80:38	.323306	57:28	.308717	39:20	.290035	98:52	0.275223	115:63	.261357	62:35	.248324	93:54	.236089
72:33	.338819	101:48	0.323080	116:57	.308583	115:59	.289846	81:43	.275017	73:40	.261262	85:48	.248178	105:61	.235860
48:22	.338819	61:29	.322932	59:29	.308454	76:39	.289749	113:60	.274927	104:57	.261158	108:61	0.248094	74:43	.235763
109:50	.338457	82:39	.322749	120:59	.308329	113:58	.289650	96:51	.274701	62:34	.260913	115:65	.247785	117:68	.235677
85:39	.338354	103:49	.322641	61:30	.308209	111:57	0.289448	64:34	.274701	93:51	.260912	92:52	.247785	86:50	.235529
61:28	0.338172	105:50	.322219	63:31	.307979	74:38	.289448	111:59	.274471	113:62	.260687	69:39	.247785	98:57	.235351
98:45	.338014	84:40	.322219	65:32	.307763	109:56	.289239	79:42	.274378	82:45	0.260601	99:56	.247447	110:64	.235213
111:51	.337753	63:30	.322219	67:33	.307561	72:37	.289131	94:50	.274158	51:28	.260412	76:43	.247345	55:32	.235213
74:34	.337753	42:20	.322219	118:58	0.307454	107:55	.289021	109:58	.273999	71:39	.260194	106:60	.247155	67:39	0.235010
87:40	.337459	107:51	.321814	69:34	.307370	70:36	.288796	62:33	.273878	91:50	.260071	53:30	.247155	79:46	.234869
100:46	.337242	86:41	.321715	71:35	.307190	103:53	.288561	77:41	0.273707	111:61	.259993	83:47	.246980	91:53	.234766
113:52	.337075	65:31	0.321552	73:36	.307020	68:35	.288441	92:49	.273592	100:55	.259637	113:64	.246898	103:60	.234686
63:29	.336943	109:52	.321423	75:37	.306860	101:52	.288318	107:57	.273509	80:44	.259637	120:68	0.246672	115:67	.234623
76:35	.336746	88:42	.321233	77:38	.306707	66:34	.288065	120:64	.273001	40:22	.259637	90:51	.246672	96:56	.234083
89:41	.336606	44:21	.321233	79:39	.306563	99:51	0.288065	105:56	.273001	109:60	.259275	60:34	.246672	84:49	.234083
102:47	0.336502	111:53	.321047	81:40	.306425	97:50	.287802	90:48	.273001	89:49	.259194	97:55	.246409	72:42	.234083
115:53	.336412	67:32	.320925	83:41	.306294	64:33	.287666	75:40	.273001	69:38	0.259066	67:38	.246291	60:35	.234083
117:54	.335792	90:43	.320774	85:42	.306170	95:49	.287528	60:32	.273001	118:65	.258969	104:59	.246181	113:66	.233535
91:42	.335792	113:54	.320685	87:43	0.306051	93:48	.287242	118:63	.272542	98:54	.258832	111:63	.245982	101:59	0.233469
78:36	.335792	115:55	.320335	89:44	.305937	62:32	.287242	103:55	.272475	78:43	.258626	74:42	.245982	89:52	.233388
65:30	.335792	92:44	.320335	91:45	.305829	91:47	.286944	88:47	0.272385	107:59	.258532	37:21	.245982	77:45	.233278
52:24	.335792	69:33	0.320335	93:46	.305725	120:62	.286790	73:39	.272258	116:64	.258278	118:67	.245807	65:38	.233130
119:55	.335184	46:22	.320335	95:47	.305626	89:46	.286632	58:31	.272066	87:48	.258278	81:46	0.245727	118:69	.233033
106:49	.335110	117:56	.319998	97:48	.305531	118:61	.286552	101:54	.271928	58:32	.258278	88:50	.245513	53:31	.232914
93:43	.335014	71:34	.319779	99:49	.305439	116:60	0.286307	86:46	.271741	96:53	.257995	95:54	.245330	94:55	.232765
80:37	0.334888	119:57	.319672	101:50	.305351	56:30	.286307	114:61	.271575	67:37	.257873	51:29	.245172	82:48	.232573
67:31	.334713	96:46	.319513	103:51	.305267	114:59	.286053	99:53	.271360	105:58	0.257761	109:62	.245035	111:65	.232410
54:25	.334454	73:35	.319255	105:52	.305186	85:44	.285966	112:60	.271067	38:21	.257564	58:33	.244914	70:41	.232314
95:44	.334271	98:47	.319128	107:53	0.305108	56:29	.285790	84:45	.271067	76:42	.257564	65:37	.244712	87:51	0.231949
82:38	.334030	100:48	.318759	109:54	.305033	83:43	.285610	56:30	.271067	85:47	.257321	72:41	.244549	58:34	.231949
110:51	.333823	75:36	.318759	111:55	.304960	110:57	.285518	97:52	0.270768	94:52	.257125	79:45	.244415	104:61	.231704
69:32	.333699	102:49	0.318404	113:56	.304890	81:42	.285236	69:37	.270647	103:57	.256962	86:49	.244302	75:44	.231608
97:45	.333559	77:37	.318289	115:57	.304823	54:28	.285235	110:59	.270541	112:62	.256826	93:53	0.244207	92:54	.231394
84:39	.333215	52:25	.318063	117:58	.304758	106:55	.284943	82:44	.270361	56:31	.256826	100:57	.244125	109:64	.231247
56:26	.333215	79:38	.317844	119:59	.304695	79:41	0.284843	41:22	.270361	65:36	.256611	107:61	.244054	63:37	.231139
99:46	0.332877	106:51	.317736	32:16		52:27	.284640	95:51	.270153	74:41	.256448	114:65	.243992	80:47	.230992
71:33	.332744	81:39	.317420	or		77:40	.284431	54:29	.269996	83:46	0.256320	119:68	.243038	97:57	.230897
114:53	.332629	110:53	.317117	any	0.301030	102:53	.284324	67:36	.269772	92:51	.256218	112:64	.243038	114:67	.230830
86:40	.332439	83:40	.317018	2 to 1		100:52	.283997	80:43	.269622	101:56	.256133	98:56	.243038	85:50	0.230449
43:20	.332439	112:54	.316824	ratio		75:39	.283997	93:50	.269513	110:61	.256063	91:52	.243038	68:40	.230449
101:47	.332224	85:41	.316635	119:60	.297396	98:51	.283656	106:57	0.269431	119:66	.256003	84:48	.243038	51:30	.230449
58:27	.332064	114:55	0.316542	117:59	.297334	73:38	.283540	119:64	.269367	99:55	.255273	77:44	.243038	107:63	.230043
73:34	.331844	87:42	.316270	115:58	.297270	96:50	.283301	117:63	.268845	90:50	.255273	70:40	0.243038	90:53	.229967
88:41	.331699	58:28	.316270	113:57	.297204	119:62	.283155	91:49	.268845	81:45	.255273	63:36	.243038	73:43	.229854
103.48	.331596	118:57	.316007	111:56	.297135	71:37	0.283057	78:42	.268845	72:40	.255273	35:20	.243038	112:66	.229674
118:55	0.331519	89:43	.315922	109:55	.297064	94:49	.282932	65:35	.268845	63:35	.255273	117:67	.242111	56:33	.229674
105:49	.330993	120:58	.315753	107:54	.296990	117:61	.282856	52:28	.268845	54:30	0.255273	110:63	.242052	95:56	.229536
90:42	.330993	60:29	.315753	105:53	.296913	92:48	.282547	39:21	.268845	115:64	.254518	103:59	.241985	117:69	.229337
75:35	.330993	91:44	.315589	103:52	0.296833	69:36	.282547	115:62	.268306	106:59	.254454	96:55	.241909	78:46	0.229337
60:28	.330993	93:45	.315270	101:51	.296751	113:59	.282226	102:55	.268238	97:54	.254378	89:51	.241820	100:59	.229148
45:21	.330993	62:30	.315270	99:50	.296665	90:47	.282145	89:48	0.268149	88:49	.254287	82:47	.241716	61:36	.229027
107:50	.330414	95:46	0.314966	97:49	.296576	67:35	.282007	76:41	.268030	79:44	.254174	75:43	.241593	83:49	.228882
92:43	.330319	64:31	.314818	95:48	.296482	111:58	.281895	63:34	.267862	70:39	.254033	68:39	0.241444	105:62	.228798
77:36	.330188	97:47	.314674	93:47	.296385	88:46	.281725	113:61	.267749	61:34	.253851	61:35	.241262	110:65	.228479
62:29	.329994	99:48	.314394	91:46	.296284	109:57	0.281552	100:54	.267606	113:63	.253738	115:66	.241154	88:52	.228479
109:51	0.329855	66:32	.314394	89:45	.296178	65:34	.281435	87:47	.267421	52:29	.253605	108:62	.241032	66:39	.228479
94:44	.329675	101:49	.314125	87:44	.296067	86:45	.281286	111:60	.267172	95:53	0.253448	54:31	.241032	115:68	.228187
47:22	.329675	68:33	.313995	85:43	.295950	107:56	.281196	74:40	.267172	86:48	.253257	101:58	.240893	93:55	.228120
79:37	.329425	103:50	.313867	83:42	0.295829	84:44	.280827	37:20	.267172	120:67	.253106	94:54	.240734	71:42	0.228009
111:52	.329320	105:51	.313619	81:41	.295701	63:33	.280827	98:53	.266950	77:43	.253022	87:50	.240549	120:71	.227923
96:45	.329059	70:34	.313619	79:40	.295567	103:54	.280443	61:33	0.266816	111:62	.252931	120:69	.240332	98:58	.227798
64:30	.329059	107:52	0.313381	77:39	.295426	82:43	.280345	85:46	.266661	102:57	.252725	80:46	.240332	76:45	.227601
113:53	.328803	72:35	.313265	75:38	.295278	61:32	.280180	109:59	.266575	68:38	.252725	113:65	0.240165	103:61	.227507
81:38	.328701	109:53	.313151	73:37	.295121	101:53	.280046	96:52	.266268	93:52	.252480	73:42	.240074	81:48	.227244
98:46	.328468	74:36	.312929	71:36	.294956	80:42	0.279841	72:39	.266268	118:66	.252338	106:61	.239976	54:32	.227244
115:54	0.328304	111:54	.312929	69:35	.294781	40:21	.279841	107:58	.265956	59:33	.252338	99:57	.239760	113:67	.227004
66:31	.328182	113:55	.312716	67:34	.294596	99:52	.279632	118:64	.265702	84:47	0.252181	66:38	.239760	86:51	.226928
83:39	.328014	76:37	.312612	65:33	.294400	59:31	.279490	59:32	.265702	109:61	.252097	92:53	.239512	59:35	.226784
100:47	.327902	115:56	.312510	63:32	0.294191	78:41	.279311	94:51	.265558	100:56	.251812	59:34	.239373	91:54	0.226648
117:55	.327823	117:57	.312311	61:31	.293968	97:51	.279202	70:38	.265314	75:42	.251812	85:49	.239223	64:38	.226396
119:56	.327359	78:38	.312311	120:61	.293851	116:61	.279128	116:63	0.265118	116:65	.251545	111:64	.239143	96:57	.226396
85:40	.327359	119:58	0.312119	59:30	.293731	95:50	.278754	81:44	.265032	91:51	.251471	78:45	.238882	101:60	.226170
68:42	.327359	80:39	.312025	116:59	.293606	76:40	.278754	92:50	.264818	66:37	.251342	52:30	0.238882	69:41	.226065
51:24	.327359	82:40	.311754	57:29	.293477	57:30	.278754	103:56	.264649	107:60	.251233	97:56	.238584	106:63	.225965
104:49	.326837	41:20	.311754	112:57	.293343	38:20	0.278754	68:37	.264307	82:46	.251056	71:41	.238474	111:66	.225779
87:41	0.326735	84:41	.311495	55:28	.293205	112:59	.278366	79:43	.264159	98:55	.250863	116:67	.238383	74:44	.225779
70:33	.326584	86:42	.311249	108:55	.293061	93:49	.278287	90:49	.264046	57:32	0.250725	90:52	.238239	116:69	.225609
89:42	.326141	43:21	.311249	53:27	.292912	74:39	.278167	101:55	.263959	73:41	.250539	109:63	.238086	79:47	.225529
108:51	.325854	88:43	.311014	104:53	0.292757	55:29	.277965	112:61	.263888	89:50	.250420	64:37	.237978	84:50	0.225309
72:34	.325854	90:44	.310790	51:26	.292597	91:48	.277800	110:60	.263241	105:59	.250337	83:48	.237837	89:53	.225114
91:43	.325573	45:22	.310790	100:51	.292430	108:57	.277549	99:54	0.263241	112:63	.249878	102:59	.237748	94:56	.224940
55:26	.325389			98:50	.292256	72:38	.277549	88:48	.263241	96:54	.249878	95:55	.237361	99:59	.224783

Machinery

run at a ratio of 3 to 1, it is implied that 3 is the driver and the gear with the largest number of teeth will be placed on the driving shaft. In so far as the use of the gear logarithm tables are concerned, it is immaterial which is the driver and which is the driven gear, and by comparing the gears selected with the ratio, no confusion should result.

Applications of Table

The following examples showing the application of the table to ordinary machine-shop work are not intended as a complete explanation of the subject. Knowledge of the construction and application of lathes, milling machines and gear-cutting machinery is taken for granted. The table is useful in the selection of gears (or pulleys) to obtain geometrical speeds, but because of the special nature of this class of work no examples will be given.

Lathe Change-gears

For calculating the change-gears to cut any lead on a lathe, the "constant" of the machine must be known. The constant of a simple change-gear lathe with a single-thread lead-screw may be considered as the number of threads per inch of the

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH—4

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
52:31	.224642	62:38	.212608	119:75	.200486	102:66	.189056	74:49	.179036	116:79	.166831	102:71	.157342	90:64	.148063
109:65	.224513	106:65	.212393	92:58	.200360	85:55	.189056	77:51	.178921	69:47	.166751	79:55	.157264	45:32	.148063
114:68	.224396	75:46	0.212304	111:70	.200225	68:44	.189056	80:53	.178811	91:62	.166650	112:78	.157123	97:69	.147923
57:34	.224396	119:73	.212224	65:41	.200130	51:33	0.189056	83:55	.178715	113:77	0.166588	56:39	.157123	104:74	0.147802
119:71	.224289	88:54	.212089	84:53	.200003	34:22	.189056	86:57	.178624	110:75	.166331	89:62	.156998	52:37	.147802
62:37	.224190	101:62	.211930	103:65	.199924	105:68	.188680	89:59	.178538	88:60	.166331	99:69	.156786	111:79	.147696
67:40	0.224015	57:35	.211807	114:72	.199572	88:57	.188608	92:61	.178458	66:45	.166331	66:46	.156786	118:84	.147603
72:43	.223864	70:43	.211630	95:60	.199572	71:46	.188501	95:63	.178383	44:30	.166331	109:76	.156613	66:47	.147446
77:46	.223733	96:59	.211419	76:48	0.199572	54:35	.188326	101:67	0.178257	107:73	.166061	76:53	0.156538	73:52	.147320
82:49	.223618	109:67	.211352	57:36	.199572	91:59	.188190	104:69	.178184	85:58	.165991	119:83	.156469	80:57	.147215
87:52	.223516	117:72	.210853	106:67	.199231	111:72	.187991	107:71	.178126	63:43	.165872	86:60	.156347	87:62	.147128
92:55	.223425	91:56	.210853	87:55	.199157	74:48	.187991	110:73	.178070	104:71	.165775	43:30	.156347	94:67	.147053
97:58	.223344	78:48	0.210853	68:43	.199040	94:61	.187798	113:75	.178017	82:56	.165626	96:67	.156196	101:72	.146989
102:61	.223270	65:40	.210853	117:74	.198954	57:37	0.187673	116:77	.177967	101:69	0.165472	106:74	.156074	108:77	0.146933
107:64	.223204	112:69	.210369	98:62	.198834	77:50	.187521	119:79	.177910	120:82	.165367	53:37	.156074	115:82	.146884
112:67	.223143	99:61	.210305	49:31	.198834	97:63	.187431	24:16		60:41	.165367	116:81	.155973	98:70	.146128
117:70	0.223088	86:53	.210223	79:50	.198657	117:76	.187372	or		79:54	.165233	63:44	.155888	91:65	.146128
100:60	.221849	73:45	.210110	109:69	.198577	100:65	.187087	any	0.176091	98:67	.165151	73:51	.155753	84:60	.146128
95:57	.221849	120:74	.209950	90:57	0.198368	80:52	.187087	3 to 2		117:80	.165096	93:65	0.155570	77:55	.146128
90:54	.221849	60:37	.209950	60:38	.198368	60:39	.187087	ratio		114:78	.164810	103:72	.155505	70:50	.146128
85:51	.221849	107:66	.209840	101:64	.198141	103:67	.186762	118:79	.174255	95:65	.164810	113:79	.155451	63:45	.146128
80:48	.221849	94:58	.209700	71:45	.198046	83:54	.186684	115:77	.174207	76:52	.164810	120:84	.154902	56:40	.146128
75:45	.221849	81:50	0.209515	112:71	.197960	63:41	.186557	112:75	.174157	57:39	.164810	110:77	.154902	49:35	.146128
70:42	.221849	115:71	.209440	82:52	.197811	106:69	0.186457	109:73	.174104	111:76	0.164509	100:70	.154902	42:30	0.146128
65:39	.221849	68:42	.209260	93:59	.197631	86:56	.186311	106:71	.174048	92:63	.164447	90:63	.154902	35:25	.146128
60:36	.221849	34:21	.209260	52:33	.197489	109:71	.186168	103:69	.173988	73:50	.164353	80:56	.154902	116:83	.145380
55:33	0.221849	89:55	.209027	115:73	.197375	66:43	.186075	100:67	.173925	108:74	.164192	70:49	.154902	109:78	.145332
50:30	.221849	55:34	.208884	63:40	.197281	89:58	.185962	97:65	.173858	54:37	.164192	60:42	.154902	102:73	.145277
118:71	.220624	76:47	.208716	74:47	0.197134	112:73	.185895	94:63	0.173787	89:61	.164060	30:21	0.154902	88:63	.145142
113:68	.220570	97:60	.208620	85:54	.197025	115:75	.185637	91:61	.173712	105:72	.163857	117:82	.154372	81:58	.145057
108:65	.220510	118:73	.208559	96:61	.196941	92:60	.185637	88:59	.173631	70:48	.163857	107:75	.154323	74:53	.144956
103:62	.220446	84:52	.208276	107:68	.196875	69:45	.185637	85:57	.173544	86:59	.163647	97:68	.154263	67:48	.144834
98:59	.220374	63:39	0.208276	118:75	.196821	46:30	.185637	82:55	.173451	102:70	.163502	87:61	.154180	120:86	.144683
93:56	.220295	113:70	.207980	110:70	.196295	95:62	0.185332	79:53	.173351	51:35	0.163502	77:54	.154097	60:43	0.144683
88:53	.220207	92:57	.207913	99:63	.196295	72:47	.185235	76:51	.173243	118:81	.163397	67:47	.153977	113:81	.144593
83:50	.220109	71:44	.207806	88:56	.196295	98:64	.185046	73:49	.173127	67:46	.163317	114:80	.153815	106:76	.144492
78:47	0.219997	100:62	.207608	77:49	.196295	49:32	.185046	70:47	.173000	83:57	.163203	57:40	.153815	53:38	.144492
73:44	.219870	50:31	.207608	66:42	.196295	75:49	.184865	67:45	.172862	99:68	.163126	104:73	.153710	99:71	.144377
68:41	.219725	79:49	.207431	55:35	0.196295	101:66	.184778	64:43	0.172712	115:79	.163071	94:66	0.153584	92:66	.144244
63:38	.219557	108:67	.207349	113:72	.195746	104:68	.184524	61:41	.172546	112:77	.162727	47:33	.153584	46:33	.144244
58:35	.219360	87:54	.207126	91:58	.195613	78:51	.184524	119:80	.172457	96:66	.162727	84:59	.153427	85:61	.144089
111:67	.219248	58:36	.207126	102:65	.195607	52:34	.184524	58:39	.172363	80:55	.162727	111:78	.153228	117:84	.143907
53:32	.219126	29:18	0.207126	69:44	.195396	118:77	.184391	113:76	.172265	64:44	.162727	74:52	.153228	78:56	.143907
101:61	.218992	95:59	.206872	58:37	.195226	107:70	0.184286	55:37	.172161	48:33	0.162727	101:71	.153063	110:79	0.143766
96:58	.218843	66:41	.206760	105:67	.195115	81:53	.184209	107:72	.172051	32:22	.162727	64:45	.152968	71:51	.143688
91:55	.218679	103:64	.206651	94:60	.194977	110:72	.184060	104:70	.171935	109:75	.162365	91:64	.152861	103:74	.143606
86:52	0.218495	111:69	.206474	47:30	.194977	55:36	.184060	52:35	.171935	93:64	.162303	118:83	.152804	96:69	.143422
81:49	.218289	74:46	.206474	83:53	.194802	84:55	.183917	101:68	.171813	77:53	.162215	108:76	.152610	64:46	.143422
119:72	.218215	119:74	.206315	119:76	0.194733	113:74	.183847	98:66	0.171682	61:42	.162081	81:57	0.152610	89:64	.143210
76:46	.218056	82:51	.206244	108:69	.194575	116:76	.183644	49:33	.171682	106:73	.161983	54:38	.152610	114:82	.143091
109:66	.217883	90:56	.206055	97:62	.194380	87:57	.183644	95:64	.171544	90:62	.161851	98:69	.152377	57:41	.143091
71:43	.217790	98:61	.205896	61:39	.194265	58:38	.183644	92:62	.171396	45:31	.161851	71:50	.152288	82:59	.142962
104:63	.217693	53:33	0.205762	86:55	.194136	119:78	.183452	46:31	.171396	119:82	.161733	115:81	.152213	107:77	.142893
66:40	.217484	114:71	.205647	111:71	.194065	90:59	0.183391	89:60	.171239	74:51	0.161662	88:62	.152091	100:72	0.142668
94:57	.217253	61:38	.205546	100:64	.193820	61:40	.183270	86:58	.171071	103:71	.161579	44:31	.152091	75:54	.142668
61.37	.217128	69:43	.205380	75:48	.193820	93:61	.183153	83:56	.170890	116:80	.161368	105:74	.151958	50:36	.142668
89:54	0.216996	77:48	.205250	50:32	.193820	96:63	.182931	120:81	.170696	87:60	.161368	61:43	.151861	118:85	.142463
117:71	.216928	85:53	.205143	114:73	.193582	64:42	.182931	80:54	.170696	58:40	.161368	78:55	.151732	93:67	.142408
112:68	.216709	93:58	.205055	89:57	0.193515	32:21	.182931	117:79	0.170559	100:69	.161151	95:67	0.151649	68:49	.142313
84:51	.216709	101:63	.204981	64:41	.193396	99:65	.182722	77:52	.170487	71:49	.161062	112:79	.151591	111:80	.142233
56:34	.216709	109:68	.204918	103:66	.193293	67:44	.182622	114:77	.170414	113:78	.160984	119:84	.151268	86:62	.142107
107:65	.216470	117:73	.204863	117:75	.193125	102:67	.182525	111:75	.170262	84:58	.160851	102:72	.151268	43:31	.142107
79:48	.216386	96:30	0.204120	78:50	.193125	105:69	.182340	74:50	.170262	97:67	.160697	85:60	.151268	104:75	.141972
102:62	.216209	88:55	.204120	92:59	.192936	70:46	0.182340	108:73	.170101	110:76	0.160579	68:48	.151268	61:44	0.141877
51:31	.216209	80:50	.204120	53:34	.192797	108:71	.182166	71:48	.170017	55:38	.160579	51:36	.151268	79:57	.141752
74:45	.216019	72:45	.204120	120:77	.192691	73:48	.182082	105:71	.169931	68:47	.160411	109:77	.150936	97:70	.141674
97:59	0.215920	64:40	.204120	67:43	.192606	111:73	.182000	68:46	.169751	81:56	.160297	92:65	.150874	115:83	.141620
120:73	.215858	56:35	.204120	81:52	.192482	114:75	.181844	99:67	.169560	94:65	.160215	75:53	.150785	108:78	.141329
115:70	.215600	32:20	.204120	95:61	0.192394	76:50	.181844	65:44	0.169461	107:74	.160152	116:82	0.150644	90:65	.141329
92:56	.215600	115:72	.203365	109:70	.192329	117:77	.181695	96:65	.169358	120:83	.160103	58:41	.150644	72:52	.141329
69:42	.215600	107:67	.203309	112:72	.191886	79:52	.181624	93:63	.169142	117:81	.159701	99:70	.150537	54:39	.141329
110:67	.215318	99:62	.203244	98:63	.191886	120:79	.181554	62:42	.169142	104:72	.159701	82:58	.150386	119:86	.141049
87:53	.215243	91:57	0.203167	94:54	.191886	82:54	.181420	31:21	.169142	91:63	.159701	106:75	.150245	101:73	.140999
64:39	.215115	83:52	.203075	70:45	.191886	85:56	0.181231	90:61	.168913	78:54	0.159701	65:46	.150156	83:60	0.140927
105:64	.215009	75:47	.202963	56:36	.191886	88:58	.181055	59:40	.168792	65:45	.159701	89:63	.150050	65:47	.140816
82:50	.214844	67:42	.202826	115:74	.191466	91:60	.180890	118:80	.168792	52:36	.159701	113:80	.149988	112:81	.140733
100:61	0.214670	59:37	.202650	101:65	.191408	94:62	.180736	87:59	.168667	114:79	.159278	120:85	.149762	94:68	.140619
118:72	.214550	110:69	.202544	87:56	.191331	47:31	.180736	115:78	.168603	101:70	.159223	96:68	.149762	47:34	.140619
59:36	.214550	51:32	.202420	73:47	0.191225	97:64	.180592	112:76	0.168404	88:61	.159153	72:51	0.149762	76:55	.140451
77:47	.214393	94:59	.202276	59:38	.191068	100:66	.180456	84:57	.168404	75:52	.159058	48:34	.149762	105:76	.140376
95:58	.214296	86:54	.202105	104:67	.190959	50:33	.180456	56:38	.168404	62:43	.158923	103:73	.149514	116:84	.140179
113:69	.214229	78:49	.201899	90:58	.190815	103:68	.180328	109:74	.168196	111:77	.158832	79:56	.149439	87:63	.140179
90:55	.213878	113:71	0.201820	76:49	.190618	106:70	.180208	81:55	.168122	98:68	.158717	110:78	.149298	58:42	.140179
72:44	.213878	116:73	.201645	107:69	.190535	53:35	0.180208	106:72	.167973	49:34	0.158717	55:39	.149298	29:21	0.140179
54:33	.213878	70:44	.201645	93:60	.190332	109:72	.180094	53:36	.167973	85:59	.158567	86:61	.149169	98:71	.139968
36:22	.213878	97:61	.201442	62:40	.190332	112:74	.179986	78:53	.167819	108:75	.158363	117:83	.149108	69:50	.139879
103:63	0.213497	62:39	.201327	110:71	.190134	53:35	.179986	103:70	.167739	72:50	.158363	93:66	.148939	109:79	.139799
67:41	.213291	89:56	.201202	79:51	.190057	115:76	.179884	100:68	.167491	95:66	.158180	62:44	.148939	120:87	.139662
116:71	.213200	116:73	.201135	96:62	0.189880	118:78	.179787	75:51	0.167491	59:41	.158068	31:22	0.148939	80:58	.139662
98:60	.213075	108:68	.200915	113:73	.189756	59:39	.179787	50:34	.167491	82:57	.157939	100:71	.148742	91:66	.139498
49:30	.213075	81:51	.200915	65:42	.189664	102:69	.179751	97:66	.167228	105:73	.157866	69:49	.148653	102:74	.139369
80:49	.212894	54:34	.200915	82:53	.189538	62:41	.179608	72:49	.167136	115:80	.157608	107:76	.148570	51:37	.139369
111:68	.212814	100:63	0.200660	99:64	.189455	65:43	.179445	119:81	.167062	92:64	.157608	114:81	.148420	113:82	.139265
93:57	.212608	73:46	.200565	116:75	.189397	68:45	0.179296	94:64	.166948	69:48	0.157608	76:54	.148420	62:45	0.139179
				119:77	.189056	71:47	.179160	47:32	.166948	46:32	.157608	83:59	.148226	73:53	.139047

Machinery

lead-screw. But modern lathes often contain permanent internal gears, and are arranged with one or two change-gear studs which must be taken into consideration in determining the constant. For any lathe with equal gears, the number of threads per inch that can be cut with equal gears on the change-gear studs is the constant of the lathe; this can usually be determined from an inspection of the index plate. On lathes equipped with quick-change gears, the constant can be easily changed.

For any lathe, $C : L$ = driver : driven gears, in which C = constant of machine and L = lead desired.

For example, what change-gears are required to cut a lead of 1.7345 threads per inch on a lathe having a constant of 4?

$$C : L = 4 : 1.7345$$

$$\log 4 = 0.602060$$
$$\log 1.7345 = 0.239174$$

$$\text{ratio log} = 0.362886$$

From the table, $\log 113 : 49 = 0.362882$

$$\text{log of ratio error} = 0.000004$$

Therefore, the driver has 113 teeth, and the driven gear, 49 teeth.

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH—5

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
84:61	.138950	112:83	.130140	70:53	.120822	118:41	.112841	56:44	.104735	91:73	.095719	60:49	.087955	95:79	.080097
95:69	.138875	85:63	.130078	103:78	.120743	70:54	.112704	42:33	.104735	86:69	.095649	71:58	.087830	107:89	.079994
106:77	.138815	116:86	.129960	99:75	.120574	92:71	.112530	28:22	.104735	81:65	.095572	82:67	.087739	113:94	.079951
117:85	.138767	58:43	0.129960	66:50	.120574	57:44	0.112422	117:92	.104398	76:61	0.095484	93:76	.087669	119:99	0.079912
118:80	.138303	89:66	.129846	95:72	.120391	79:61	.112297	103:81	.104352	71:57	.095383	104:85	.087614	30:25	
99:72	.138303	120:89	.129791	62:47	.120294	101:78	.112227	89:70	.104292	66:53	.095268	115:94	.087570	or	
88:64	.138303	93:69	.129634	91:69	.120192	110:85	.111974	75:59	.104209	61:49	.095134	110:90	.087150	any	.079181
77:56	.138303	62:46	.129634	120:91	.120140	88:68	.111974	61:48	.104089	117:94	.095058	99:81	.087150	6 to 5	
66:48	0.138303	97:72	.129439	116:88	0.119975	44:34	.111974	108:85	0.104005	56:45	.094976	88:72	0.087150	ratio	
55:40	.138303	66:49	.129348	87:66	.119975	66:51	.111974	94:74	.103896	107:86	.094885	77:63	.087150	115:96	.078427
44:32	.138303	101:75	.129260	58:44	.119975	119:92	.111759	47:37	.103896	102:82	.094786	66:54	.087150	109:91	.078385
114:83	.137827	105:78	.129095	29:22	.119975	97:75	.111710	80:63	.103750	51:41	.094786	55:45	.087150	103:86	.078339
103:75	.137776	70:52	.129095	112:85	.119799	75:58	.111633	113:89	.103688	97:78	.094677	44:36	.087150	97:81	.078287
92:67	.137713	109:81	0.128942	83:63	.119738	106:82	0.111492	99:78	.103541	92:74	0.094556	116:95	.086734	91:76	0.078228
81:59	.137633	74:55	.128869	108:82	.119610	53:41	.111492	66:52	.103541	46:37	.094556	105:86	.086691	85:71	.078161
70:51	.137528	113:84	.128799	54:41	.119610	84:65	.111366	118:93	.103399	87:70	.094421	94:77	.086637	79:66	.078083
118:86	.137384	117:87	.128667	79:60	.119476	115:89	.111308	85:67	.103344	82:66	.094270	83:68	.086569	73:61	.077993
59:43	.137384	78:58	.128667	104:79	.119406	93:72	.111151	104:82	.103219	41:33	.094270	72:59	.086481	67:56	.077887
107:78	0.137289	82:61	.128484	100:76	0.119186	62:48	.111151	52.41	0.103219	118:95	.094158	61:50	0.086360	61:51	.077760
96:70	.137173	86:64	.128319	75:57	.119186	102:79	.110973	90:71	.102984	77:62	.094099	111:91	.086282	116:97	.077686
48:35	.137173	43:32	.128319	50:38	.119186	71:55	.110896	109:86	.102928	113:91	.094037	100:82	.086186	55:46	.077605
85:62	.137027	90:67	.128168	96:73	.118948	111:86	.110825	95:75	.102662	108:87	.093905	50:41	.086186	104:87	.077514
111:81	.136838	94:70	.128030	71:54	.118865	120:93	.110698	76:60	.102662	72:58	.093905	89:73	.086067	98:82	.077412
74:54	.136838	47:35	0.128030	117:89	.118796	80:62	0.110698	57:45	.102662	103:83	0.093759	117:96	.085915	49:41	0.077412
100:73	.136677	98:73	.127903	92:70	.118690	40:31	.110698	38:30	.102662	67:54	.093681	78:64	.085915	92:77	.077297
63:46	.136583	102:76	.127787	46:35	.118690	89:69	.110541	119:94	.102419	98:79	.093599	39:32	.085915	86:72	.077166
89:65	.136477	51:38	.127787	113:86	.118580	98:76	.110413	100:79	.102373	93:75	.093422	106:87	.085787	43:36	.077166
115:84	.136419	106:79	.127679	67:51	.118505	49:38	.110413	81:64	.102305	62:50	.093422	67:55	.085712	80:67	.077015
104:76	0.136220	110:82	.127579	88:67	0.118408	107:83	.110306	62:49	0.102196	119:96	.093276	95:78	0.085629	117:98	.076960
78:57	.136220	55:41	.127579	109:83	.118348	116:90	.110216	105:83	.102111	88:71	.093224	112:92	.085430	111:93	.076840
52:38	.136220	114:85	.127486	84:64	.118099	58:45	.110216	86:68	.101990	114:92	.093117	84:69	.085430	74:62	.076840
119:87	.136028	118:88	.127399	63:48	.118099	67:52	.110072	43:34	.101990	57:46	.093117	56:46	.085430	37:31	.076840
93:68	.135974	59:44	.127399	42:32	.118099	76:59	.109962	110:87	.101873	83:67	.093003	28:23	.085430	105:88	.076707
67:49	.135879	63:47	0.127243	101:77	.117831	85:66	0.109875	67:53	.101799	109:88	0.092944	101:83	.085243	68:57	0.076634
108:79	.135797	67:50	.127105	80:61	.117760	94:73	.109805	91:72	.101709	104:84	.092754	118:97	.085110	99:83	.076557
82:60	.135663	71:53	.126982	118:90	.117640	103:80	.109747	115:91	.101656	78:63	.092754	90:74	.085011	93:78	.076388
41:30	.135663	75:56	.126873	59:45	.117640	112:87	.109699	120:95	.101458	52:42	.092754	45:37	.085011	62:52	.076388
97:71	.135513	79:59	.126775	97:74	.117540	117:91	.109145	96:76	.101458	26:21	.092754	107:88	.084901	118:99	.076247
112:82	0.135404	83:62	.126686	114:87	0.117386	108:84	.109145	72:57	0.101458	99:80	.092545	62:51	0.084822	87:73	.076196
56:41	.135404	87:65	.126606	76:58	.117386	99:77	.109145	48:38	.101458	73:59	.092471	79:65	.084714	112:94	.076090
71:52	.135255	91:68	.126533	93:71	.117225	90:70	.109145	101:80	.101231	120:97	.092410	96:79	.084644	56:47	.076090
86:63	.135158	95:71	.126465	110:84	.117113	81:63	.109145	77:61	.101161	94:76	.092314	113:93	.084596	81:68	.075976
101:74	.135090	99:74	.126404	55:42	.117113	72:56	.109145	106:84	.101027	47:38	.092314	119:98	.084321	106:89	.075916
116:85	.135039	103:77	0.126347	105:80	.117099	63:49	0.109145	53:42	.101027	68:55	0.092146	102:84	.084321	100:84	0.075721
105:77	.134699	107:80	.126294	72:55	.116970	54:42	.109145	82:65	.100901	115:93	.092215	85:70	.084321	75:63	.075721
90:66	.134699	111:83	.126245	89:68	.116881	45:35	.109145	111:88	.100840	89:72	.092058	68:56	.084321	50:42	.075721
75:55	.134699	115:86	.126199	106:81	0.116821	27:21	.109145	116:92	.100670	110:89	.092003	51:42	.084321	25:21	.075721
60:44	.134699	119:89	.126157	119:91	.116506	113:88	.108596	87:69	.100670	105:85	.091770	108:89	.084034	119:100	.075547
45:33	0.134699	120:90	.124939	102:78	0.116506	104:81	.108548	58:46	0.100670	84:68	.091770	91:75	0.083980	94:79	.075501
30:22	.134699	112:84	.124939	85:65	.116506	95:74	.108492	29:23	.100670	63:51	.091770	74:61	.083902	69:58	.075421
109:80	.134337	108:81	.124939	68:52	.116506	86:67	.108424	92:73	.100465	42:34	.091770	114:94	.083777	113:95	.075355
94:69	.134279	104:78	.124939	51:39	.116506	77:60	.108339	63:50	.100371	116:94	.091330	57:47	.083777	88:74	.075251
79:58	.134199	88:66	.124939	34:26	.116506	68:53	.108233	97:77	.100281	58:47	.091330	97:80	.083682	44:37	.075251
64:47	.134082	84:63	0.124939	115:88	.116215	118:92	0.108094	102:81	.100115	95:77	0.091233	120:99	.083546	107:90	0.075141
113:83	.134000	64:48	.124939	98:75	.116165	59:46	.108094	68:54	.100115	111:90	.091080	80:66	.083546	63:53	.075065
98:72	.133894	60.45	.124939	81:62	.116093	109:85	.108008	34:27	.100115	74:60	.091080	40:33	.083546	82:69	.074965
49:36	.133894	44:33	.124939	64:49	.115984	100:78	.107905	107:85	.099964	37:30	.091080	103:85	.083418	101:85	.074903
83:61	.133748	40:30	.124939	111:85	.115904	50:39	.107905	73:58	.099894	90:73	.090920	63:52	.083337	114:96	.074634
117:86	0.133687	28:21	.124939	94:72	0.115795	91:71	.107783	112:89	0.099828	106:86	.090807	86:71	0.083240	95:80	.074634
102:75	.133539	117:88	.123703	47:36	.115795	82:64	.107634	78:62	.099703	53:43	.090807	109:90	.083184	76:64	.074634
68:50	.133539	113:85	.123660	77:59	.115639	41:32	.107634	39:31	.099703	69:56	.090661	115:95	.082974	57:48	.074634
87:64	.133339	109:82	.123613	107:82	.115570	114:89	.107515	83:66	.099534	85:69	.090570	92:76	.082974	38:32	.074634
106:78	.133211	105:79	.123562	120:92	.115393	73:57	.107448	88:70	.099385	101:82	.090508	69:57	.082974	108:91	.074382
72:53	.133057	101:76	0.123508	90:69	.115393	105:82	0.107375	44:35	.099385	117:95	0.090462	46:38	.082974	89:75	0.074329
91:67	.132967	97:73	.123449	60:46	.115393	96:75	.107210	93:74	.099251	112:91	.090177	98:81	.082741	70:59	.074246
110:81	.132908	93:70	.123385	30:23	.115393	64:50	.107210	98:78	.099132	96:78	.090177	75:62	.082670	102:86	.074102
114:84	.132626	89:67	.123315	103:79	.115210	119:93	.107064	49:39	.099132	80:65	.090177	52:43	.082535	51:43	.074102
95:70	.132626	85:64	.123238	73:56	.115135	87:68	.107010	103:82	.099023	64:52	.090177	81:67	.082410	83:70	.073980
76:56	0.132626	81:61	.123155	116:89	0.115068	110:86	.106894	108:86	0.098925	48:39	.090177	110:91	0.082351	115:97	.073927
57:42	.132626	77:58	.123063	86:66	.114955	55:43	.106894	54:43	.098925	107:87	.089865	116:96	.082187	96:81	.073786
118:87	.132363	73:55	.122960	43:33	.114955	78:61	.106765	113:90	.098836	91:74	.089810	87:72	.082187	64:54	.073786
99:73	.132312	69:52	.122846	99:76	.114822	101:79	.106694	118:94	.098754	75:61	.089732	58:48	.082187	109:92	.073639
80:59	.132238	65:49	.122717	112:86	.114720	115:90	.106455	59:47	.098754	118:96	.089611	29:24	.082187	77:65	.073577
61:45	.132117	61:46	0.122572	56:43	.114720	92:72	0.106455	64:51	.098610	59:48	0.089611	93:77	.081992	90:76	0.073429
103:76	.132024	118:89	.122492	69:53	.114573	69:54	.106455	69:55	.098486	102:83	.089522	64:53	.081904	45:38	.073429
84:62	.131888	114:86	.122406	82:63	.114473	46:36	.106455	74:59	.098380	86:70	.089401	99:82	.081821	103:87	.073318
42:31	.131888	57:43	.122406	95:73	.114401	106:83	.106228	79:63	.098287	43:35	.089401	105:87	.081670	116:98	.073232
107:79	.131757	110:83	.122315	108:83	.114346	83:65	.106165	84:67	.098205	113:92	.089291	70:58	.081670	58:49	.073232
65:48	0.131672	53:40	.122216	117:90	0.113943	120:94	.106053	89:71	0.098132	70:57	.089223	76:63	0.081473	71:60	.073107
88:65	.131570	106:80	.122216	104:80	.113943	60:47	.106053	94:75	.098067	97:79	.089145	117:97	.081414	84:71	.073021
111:82	.131509	102:77	.122110	91:70	.113943	97:76	.105958	99:79	.098008	108:88	.088941	82:68	.081305	97:82	.072958
115:85	.131279	98:74	.121994	78:60	.113943	111:87	.105804	104:83	.097955	81:66	.088941	41:34	.081305	110:93	.072910
92:68	.131279	49:37	.121994	65:50	.113943	74:58	.105804	109:87	.097907	54:44	.088941	88:73	.081160	117:99	.072551
69:51	.131279	94:71	0.121870	52:40	.113943	88:69	0.105634	114:91	.097864	27:22	0.088941	94:78	.081033	104:88	0.072551
46:34	.131279	90:68	.121734	39:30	.113943	102:80	.105510	119:95	.097823	119:97	.088775	47:39	.081033	91:77	.072551
119:88	.131064	45:34	.121734	26:20	.113943	51:40	.105510	20:16		65:53	.088638	100:83	.080922	78:66	.072551
96:71	.131013	86:65	.121585	113:87	.113559	116:91	.105417	or		103:84	.088558	106:88	.080823	65:55	.072551
73:54	.130929	82:62	.121422	100:77	.113509	65:51	.105343	any	0.096910	114:93	.088422	53:44	.080823	39:33	.072551
100:74	0.130768	41:31	.121422	87:67	0.113445	79:62	.105235	5 to 4		76:62	.088422	118:98	0.080656	52:34	.072551
50:37	.130768	119:90	.121305	74:57	.113357	93:73	.105160	ratio		38:31	.088422	59:48	.080656	111:94	.072195
77:57	.130616	78:59	.121243	61:47	.113232	107:84	.105105	116:93	.095975	87:71	.088261	65:54	.080510	98:83	.072148
104:77	.130543	115:87	.121179	109:84	.113147	112:88	.104735	111:89	.095933	98:80	.088136	71:59	.080406	85:72	.072086
81:60	.130334	111:84	.121044	96:74	.113040	98:77	.104735	106:85	.095887	49:40	.088136	77:64	.080311	72:61	.072003
54:40	.130334	74:56	0.121044	48:37	.113040	84:66	0.104735	101:81	.095836	109:89	0.088037	83:69	.080229	118:100	0.071882
27:20	.130334	107:81	.120899	83:64	.112898	70:55	.104735	96:77	.095781	120:98	.087955	89:74	.080158	59:50	.071882

Machinery

Milling-machine Change-gears

Milling-machine change-gears required for such work as cutting helical or herringbone gears accurately are solved in a similar way to lathe change-gears. The constant of a milling machine is the lead cut with equal gears on the worm and stud. With four threads per inch on the feed-screw and a 40-tooth worm-wheel and single-thread worm (the usual combination on a milling machine), the constant is one-fourth of 40, or 10. For any milling machine, $C : L =$ driver (feed-screw gear) : driven gear (worm-shaft gear), in which C is the constant or lead of the machine, and L, the lead of spiral to be cut.

Hobbing Spiral Gears

In problems of this nature, the gear logarithms are particularly valuable, as two gear ratios must be synchronized. The feed of the hob and the rate of rotation of the blank are interrelated, and gears must be found that will equal the desired feed; this feed also must be calculated in connection with the formula for index gears. The internal gears and arrangement

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH-6

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
92:78	.071693	96:83	.063193	51:45	.054358	40:36	0.045758	37:34	.036723	32:30	0.028029	47:45	.018885	44:43	0.009984
46:39	.071693	74:64	.063052	34:30	.054358	111:100	.045323	99:91	.036594	97:91	.027730	71:68	.018749	89:87	.009871
79:67	.071552	37:32	0.063052	111:98	.054097	101:91	.045280	62:57	.036517	81:76	.027671	95:91	.018682	90:88	.009760
112:95	.071494	89:77	.062899	94:83	.054050	91:82	.045228	87:80	.036429	65:61	.027584	96:92	.018483	45:44	.009760
99:84	.071356	52:45	.062791	77:68	.053982	81:73	.045162	100:92	.036212	98:92	.027438	72:69	0.018483	91:89	.009651
66:56	.071356	67:58	.062647	60:53	.053875	71:64	.045078	75:69	0.036212	82:77	.027438	48:46	.018483	92:90	.009545
105:89	.071799	82:71	.062556	103:91	0.053796	61:55	.044967	50:46	.036212	49:46	.027438	24:23	.018483	46:45	.009545
86:73	.071176	97:84	.062493	86:76	.053685	51:46	.044812	88:81	.035998	99:93	.027152	97:93	.018289	93:91	.009442
106:90	0.071063	112:97	.062446	43:38	.053685	92:83	.044710	63:58	.035913	66:62	.027152	73:70	.018225	94:92	.009340
53:45	.071063	90:78	.062148	112:99	.053583	82:74	.044582	101:93	.035839	33:31	.027152	98:94	.018098	47:46	.009340
73:62	.070931	75:65	.062148	69:61	.053519	41:37	0.044582	76:70	.035716	83:78	0.026984	49:47	.018098	95:93	0.009241
93:79	.070856	60:52	.062148	95:84	.053444	72:65	.044419	38:35	.035716	100:94	.026872	74:71	.017973	96:94	.009143
113:96	.070808	45:39	0.062148	78:69	.053246	103:93	.044354	89:82	.035576	50:47	.026872	99:95	.017912	48:47	.009143
100:85	.070581	113:98	.061852	52:46	.053246	93:84	.044204	51:47	.035472	67:63	.026734	100:96	.017729	97:95	.009048
80:68	.070581	98:85	.061807	113:100	.053078	62:56	.044204	64:59	.035328	84:79	.026652	75:72	.017729	98:96	.008955
60:51	.070581	83:72	.061746	87:77	.053029	83:75	.044017	77:71	0.035232	101:95	.026598	50:48	0.017729	49:48	.008955
40:34	.070581	68:59	.061657	61:54	0.052936	52:47	.043905	90:83	.035164	85:80	.026329	101:97	.017550	99:97	.008864
107:91	.070342	53:46	.061518	96:85	.052852	73:66	.043779	103:95	.035114	68:64	.026329	76:73	.017491	100:98	.008774
87:74	0.070288	91:79	.061414	70:62	.052706	94:85	.043709	91:84	.034762	51:48	.026329	51:49	.017374	50:49	.008774
67:57	.070200	76:66	.061270	35:31	.052706	84:76	.043466	78:72	.034762	34:32	.026329	77:74	.017259	101:99	.008686
114:97	.070133	38:33	.061270	79:70	.052529	63:57	0.043466	65:60	.034762	103:97	0.026066	103:99	.017202	51:50	0.008600
94:80	.070038	99:86	.061137	88:78	.052388	42:38	.043466	52:48	.034762	86:81	.026014	78:75	.017033	52:51	.008433
47:40	.070038	61:53	0.061054	44:39	.052388	95:86	.043225	39:36	.034762	69:65	.025936	52:50	.017033	53:52	.008273
74:63	.069891	84:73	.060956	97:86	.052273	74:67	.043157	105:97	.034418	52:49	.025807	79:76	.016814	54:53	.008118
101:86	.069823	107:93	.060901	53:47	.052178	53:48	.043035	92:85	.034369	87:82	.025705	53:51	.016706	55:54	.007969
81:69	.069636	92:80	.060698	62:55	.052029	85:77	.042928	79:73	0.034304	70:66	.025554	80:77	0.016599	56:55	.007825
54:46	.069636	69:60	.060698	71:63	0.051918	96:87	.042752	66:61	.034214	35:33	.025554	81:78	.016391	57:56	.007687
115:98	.069472	46:40	.060698	80:71	.051832	64:58	.042752	53:49	.034080	88:83	.025405	54:52	.016391	58:57	.007553
88:75	0.069421	100:87	.060481	89:79	.051763	107:97	.042612	93:86	.033984	53:50	.025306	82:79	.016187	59:58	.007424
61:52	.069327	77:67	.060416	98:87	.051707	75:68	.042552	80:74	.033858	71:67	.025184	55:53	.016087	60:59	.007299
95:81	.069239	54:47	.060296	107:95	.051660	86:78	0.042404	40:37	.033858	89:84	0.025111	83:80	.015988	61:60	0.007179
68:58	.069081	85:74	.060187	99:88	.051153	43:39	.042404	107:99	.033749	90:85	.024824	84:81	.015794	62:61	.007062
109:93	.068944	93:81	0.059998	90:80	.051153	97:88	.042289	67:62	.033683	72:68	.024824	56:54	.015794	63:62	.006949
75:64	.068881	62:54	.059998	81:72	.051153	54:49	.042198	94:87	.033609	54:51	.024824	85:82	.015605	64:63	.006840
116:99	.068823	101:88	.059839	72:64	.051153	65:59	.042061	81:75	.033424	36:34	.024824	57:55	.015512	65:64	.006733
82:70	.068716	70:61	.059768	63:56	.051153	76:69	.041965	54:50	0.033424	91:86	.024543	86:83	0.015420	66:65	.006631
41:35	.068716	109:95	.059703	54:48	0.051153	87:79	.041892	95:88	.033241	73:69	.024474	87:84	.015240	67:66	.006531
89:76	.068576	78:68	.059586	45:40	.051153	98:89	.041836	68:63	.033168	55:52	.024359	58:56	.015240	68:67	.006434
96:82	0.068457	39:34	.059586	36:32	.051153	109:99	.041791	82:76	.033000	92:87	.024269	88:85	.015064	69:68	.006340
48:41	.068457	86:75	.059437	109:97	.050655	99:90	.041393	41:38	.033000	74:70	.024134	59:57	.014977	70:69	.006249
103:88	.068355	97:41	.059314	100:89	.050610	88:80	0.041393	96:89	.032881	37:35	0.024134	89:86	.014892	71:70	0.006160
55:47	.068265	94:82	.059314	91:81	.050556	77:70	.041393	55:51	.032793	93:88	.024000	90:87	.014723	72:71	.006074
117:100	.068186	102:89	0.059210	82:73	.050491	66:60	.041393	69:64	.032669	56:53	.023912	60:58	.014723	73:72	.005990
62:53	.068116	55:48	.059122	73:65	.050410	55:50	.041393	83:77	.032587	75:71	.023803	91:88	.014559	74:73	.005909
69:59	.067997	63:55	.058978	64:57	.050305	44:40	.041393	97:90	.032529	94:89	.023738	61:59	.014478	75:74	.005830
76:65	.067900	71:62	.058867	55:49	.050167	33:30	.041393	98:91	0.032185	95:90	.023481	92:89	0.014398	76:75	.005752
83:71	.067820	79:69	.058778	101:90	0.050079	100:91	.040959	84:78	.032185	76:72	.023481	93:90	.014240	77:76	.005677
90:77	.067752	87:76	.058706	92:82	.049974	89:81	.040905	70:65	.032185	57:54	.023481	62:60	.014240	78:77	.005604
97:83	0.067694	95:83	.058646	46:41	.049974	78:71	.040836	56:52	.032185	38:36	.023481	31:30	.014240	79:78	.005533
104:89	.067643	103:90	.058595	83:74	.049846	67:61	.040745	42:39	.032185	96:91	.023230	94:91	.014087	80:79	.005463
111:95	.067599	96:84	.057992	74:66	.049688	56:51	0.040618	99:92	.031847	77:73	0.023168	63:61	.014011	81:80	0.005395
98:84	.066947	88:77	.057992	37:33	.049688	101:92	.040534	85:79	.031792	58:55	.023065	95:92	.013936	82:81	.005329
91:78	.066947	80:70	0.057992	102:91	.049558	90:82	.040429	71:66	.031714	97:92	.022984	96:93	.013788	83:82	.005264
84:72	.066947	72:63	.057992	65:58	.049485	45:41	.040429	57:53	.031599	78:74	.022863	64:62	.013788	84:83	.005201
77:66	.066947	64:56	.057992	93:83	.049405	79:72	.040295	100:93	.031517	39:37	.022863	32:31	.013788	85:84	.005140
70:60	.066947	56:49	.057992	56:50	.049218	68:62	.040117	86:80	0.031409	98:93	.022743	97:94	0.013644	86:85	.005080
63:54	.066947	48:42	.057992	84:75	0.049218	34:31	.040117	43:40	.031409	59:56	.022664	65:63	.013573	87:86	.005021
56:48	.066947	40:35	.057992	103:92	.049049	91:83	.039963	72:67	.031258	79:75	.022566	98:95	.013503	88:87	.004963
49:42	0.066947	113:99	.057443	75:67	.048987	57:52	.039872	101:94	.031194	99:94	.022507	99:96	.013364	89:88	.004907
42:36	.066947	105:92	.057402	94:84	.048849	80:73	.039767	87:81	.031034	100:95	.022276	66:64	.013364	90:89	.004853
35:30	.066947	97:85	.057353	47:42	.048849	103:94	0.039709	58:54	.031034	80:76	0.022276	33:32	.013364	91:90	0.004799
113:97	.066307	89:78	.057295	66:59	.048692	92:84	.039509	102:95	.030877	60:57	.022276	100:97	.013228	92:91	.004746
106:91	.066265	81:71	0.057227	85:76	.048605	69:63	.039509	73:68	.030814	40:38	.022276	67:65	.013161	93:92	.004695
99:85	.066216	73:64	.057143	104:93	.048550	46:42	.039509	88:82	.030669	28:26	.022185	101:98	.013095	94:93	.004645
92:79	.066161	65:57	.057039	95:85	.048305	104:95	.039310	44:41	.030669	101:96	.022050	68:66	.012965	95:94	.004596
85:73	.066096	57:50	.056905	76:68	.048305	81:74	.039253	103:96	0.030566	81:77	.021994	34:33	0.012965	96:95	.004548
78:67	.066020	106:93	.056823	57:51	0.048305	58:53	.039152	59:55	.030489	61:58	.021902	103:100	.012837	97:96	.004501
71:61	.065929	98:86	.056728	38:34	.048305	93:85	.039064	74:69	.030383	103:98	.021611	69:67	.012774	98:97	.004454
64:55	0.065817	49:43	.056728	105:94	.048061	105:96	.038918	89:83	.030312	62:59	.021540	70:68	.012589	99:98	.004409
57:49	.065679	90:79	.056615	86:77	.048008	70:64	.038918	104:97	.030262	83:79	.021451	35:34	.012589	100:99	.004365
107:92	.065596	82:72	.056481	67:60	.047924	35:32	0.038918	105:98	.029963	104:99	0.021398	72:70	.012235	101:100	0.004321
100:86	.065502	41:36	.056481	96:86	.047773	82:75	.038753	90:84	.029963	84:80	.021189	36:35	.012235	102:101	.004279
50:43	.065502	74:65	0.056318	48:43	.047773	94:86	.038629	75:70	.029963	63:60	.021189	73:71	.012065	103:102	.004237
93:80	.065393	107:94	.056256	77:69	.047642	47:32	.038629	60:56	.029963	42:40	.021189	74:72	.011899	104:103	.004196
86:74	.065267	99:87	.056116	106:95	.047582	106:97	.038534	45:42	.029963	85:81	.020934	37:36	.011899	105:104	.004156
43:37	.065267	66:58	.056116	87:78	.047425	59:54	.038458	106:99	0.029671	64:61	.020850	75:73	0.011738	106:105	.004117
79:68	.065118	91:80	.055951	58:52	0.047425	71:65	.038345	91:85	.029623	86:82	.020685	76:74	.011582	107:106	.004078
115:99	.065063	58:51	.055858	29:26	.047425	83:76	.038265	76:71	.029555	43:41	.020685	38:37	.011582	108:107	.004040
72:62	0.064941	83:73	.055755	97:87	.047252	95:87	.038204	61:57	.029455	65:62	.020522	77:75	.011429	109:108	.004002
36:31	.064941	108:95	.055700	39:35	.046997	107:98	.038158	107:100	.029384	87:83	.020441	78:76	.011281	110:109	.003967
101:87	.064802	100:88	.055517	88:79	.046856	96:88	.037789	92:84	.029289	88:84	0.020203	39:38	.011281	111:110	0.003930
65:56	.064725	75:66	.055517	98:88	.046743	84:77	0.037789	46:43	.029289	66:63	.020203	79:77	.011136	112:111	.003895
94:81	.064643	50:44	0.055517	49:44	.046743	72:66	.037789	77:72	.029158	44:42	.020203	80:78	.010995	113:112	.003860
87:75	.064458	92:81	.055303	108:97	.046652	60:55	.037789	93:87	.028964	89:85	.019971	40:39	.010995	114:113	.003827
109:94	.064299	67:59	.055223	59:53	.046576	48:44	.037789	62:58	.028964	67:64	.019895	81:79	.010858	115:114	.003793
80:69	.064241	109:96	.055155	69:62	.046457	36:33	.037789	78:73	0.028772	90:86	.019744	82:80	0.010724	116:115	.003760
102:88	.064118	84:74	.055048	79:71	0.046369	109:100	.037427	97:44	.028645	45:43	.019744	41:40	.010724	117:116	.003728
51:44	.064118	42:37	.055048	89:80	.046300	97:89	.037382	94:88	.028645	68:65	.019596	83:81	.010593	118:117	.003696
73:63	0.063982	101:89	.054931	99:89	.046245	85:79	.037324	63:59	.028489	91:87	.019522	84:82	.010465	119:118	.003665
95:82	.063910	59:52	.054849	109:98	.046200	73:67	.037248	79:74	.028395	92:88	.019305	42:41	.010465	120:119	.003634
88:76	.063669	76:67	.054739	100:90	.045758	61:56	0.037142	95:89	.028334	69:66	0.019305	85:83	.010341		
66:57	.063669	93:82	.054669	90:81	.045758	98:90	.036984	96:90	.028029	46:44	.019305	86:84	.010219		
44:38	.063669	110:97	0.054621	80:72	.045758	49:45	.036984	80:75	.028029	93:89	.019093	43:42	.010219		
103:89	.063447	102:90	.054358	70:63	.045758	86:79	.036871	64:60	.028029	70:67	.019023	87:85	.010100		
81:70	.063387	85:75	.054358	60:54	.045758	74:68	.036723	48:45	.028029	94:90	.018885	88:86	.009984		
59:51	.063282	68:60	.054358	50:45	.045758										

Machinery

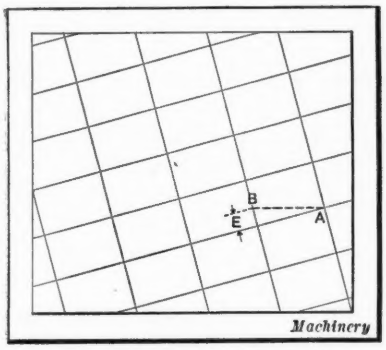


Diagram representing Developed Surface of Spiral Fluted Hob

of driver and driven gears make a general formula covering all makes of gear hobbers impractical. The gear-logarithm method applied to the Barber-Colman machine was published in MACHINERY, June, 1916, under the title "Calculating Change-gears for Hobbing Spiral Gears," and the gear logarithms for all gears supplied with these machines were given. If special gears are necessary, these tables may be used.

Relieving Spiral Fluted Hobs

The problem of relieving hobs that have been fluted at right angles to the thread is an example of the special application of the gear logarithms to difficult problems. The usual method is to alter the angle of the spiral flutes to agree with previously calculated change-gears for the relieving attachment. This only throws the problem to the milling machine, it being necessary in many cases to provide special gears to cut the lead of the flutes accurately. The problem is represented in the accompanying diagram. In one revolution the tool travels from A to B, which is the distance E beyond the flute. Therefore the ratio between the hob and the relieving attachment cam is:

$$(N + \sin^2 a) : C = \text{driver} : \text{driven gears}$$

$$\text{Tan}\, a = \frac{\text{C.P.}}{H_c}$$

in which N = number of flutes in hob;
a = angle of thread (usually stamped on hob);
C = constant of relieving attachment;
C.P. = circular pitch, corresponding to pitch of hob;
H_c = hob circumference, or 3.1416 × outside diameter.

The constant of a relieving attachment can be found on its index plate, and is determined by the number of flutes that require equal gears on the change-gear studs. This will vary with different makes of lathes, some relieving attachments having cams with different numbers of risers.

The following example shows the method of finding the change-gears to use for relieving a spiral fluted hob: What four change-gears must be used to relieve a spiral fluted hob, 10 diametral pitch, 2½ inches in diameter, 2 degrees, 17 minutes, 30 seconds angle of thread, with six spiral flutes, on a relieving attachment having a constant of 4?

$$\text{Sin 2 degrees, 17 minutes, 30 seconds} = 0.03998;$$

$$0.03998^2 = 0.001598;$$

$$\frac{6 + 0.001598}{4} = \frac{6.001598}{4}$$

$$\log 6.001598 = 0.778267$$
$$\log 4 = 0.602060$$

$$\text{log ratio} = 0.176207$$
$$\text{From the tables, log } 79 : 61 = 0.112297$$

$$\text{Subtracting from the log ratio} = 0.063910$$
$$\text{From table, log } 95 : 82 = 0.063910$$

$$\text{Therefore, the gears } \frac{79}{61} \times \frac{95}{82} = \frac{\text{drivers}}{\text{driven}} \text{ may be used.}$$

The accuracy of the gear-logarithm method of determining the change-gear ratios shown in the foregoing example is indicated by the fact that when using seven-place logs the ratio error is log 0.0000002 in the gears selected. It is hardly necessary to say that backlash in the lathe gears, spring of the relieving tool and inaccuracy of the lead-screw are items of greater inaccuracy than this.

* * *

The exports of ball bearings from Sweden to the United States increased in value from $1,004,345, in 1915, to $1,367,761 in 1916.

EXPORTS OF MUNITIONS

There are persons who would have the American people believe that the increase of our exports from $2,484,000,000, in 1913, to $5,481,000,000, last year, was due almost wholly to shipments of munitions. But the following, taken from official reports, shows the share of munitions in this trade:

	1916	1913
Total	$5,481,423,589	$2,484,018,292
Agricultural products	1,488,195,846	1,071,401,508
Foodstuffs	1,069,339,383	494,414,640
Supplies	924,599,000	218,637,000
Cotton	543,529,808	575,488,000
Breadstuffs	471,952,100	203,391,856
Meat and dairy products	279,198,960	157,486,409
Mineral oils	201,732,563	149,316,400

The head "supplies" covers metal machinery, chemicals, shoes, horses, brass, and copper. Neutrals received a part of these exports and a part was used by belligerents in normal ways. The values of the munitions exported and other products associated with the war are as follows:

	1916	1913
Munitions	$813,791,000	$20,794,000
Accessories	131,128,000	28,907,000
Total	$944,919,000	$49,701,000

It is impossible to classify the exports with absolute certainty concerning their relation to the war. Under the head of munitions are explosives, firearms, airplanes, and barbed wire. The accessories include automobiles (not all of which were war material), motorcycles, and surgical instruments. The exports of munitions as to which there is no room for doubt, were only about one-seventh, or 14¾ per cent, of the total; in 1914, they were less than one-fifteenth, or 6½ per cent. If all the "supplies" and doubtful items are included, the sum of the shipments would be only about one-third of the total in 1916, and less than one-quarter of the total in the preceding year. A large part of the export increase from $2,484,000,000 to $5,481,000,000 was due to the growing sales of foodstuffs, which shows a gain of $574,000,000. The greatest profits due to the war have been those of millions of American agriculturists, wage earners, and manufacturers of all kinds of goods for ordinary consumption. Exports do not show these enormous gains, and in no way can they be accurately measured. For example, the abnormal foreign demand has largely increased the prices of grain and cotton; five cents a pound more for cotton means an addition of about $300,000,000 for the recent crop, and 75 cents more a bushel for wheat is not far from $450,000,000.—*New York Times.*

* * *

METALS AND ALLOYS INVESTIGATION

The Bureau of Standards, Washington, D. C., has undertaken to record the present state of knowledge and practice concerning the data on the properties of metals and alloys used by engineers and others, with the view of making generally available the most acceptable values of the constants and also as a basis for further experimental investigation. Forms are being sent out requesting the name of metals and alloys; condition (whether annealed or hard drawn); chemical composition; density; shrinkage; tensile strength; yield point; elastic limit; elongation; reduction of area; Brinell hardness; scleroscope hardness; behavior in compressing; frictional coefficient (steel); abrasion resistance; melting range; coefficient of expansion; specific heat; thermal conductivity; electrical conductivity; temperature resistance coefficient; resistance to corrosion; hydraulic properties; etc.

Some of the alloys for which data are particularly desired are aluminum and its light alloys with zinc, copper, etc., of stated percentages; nickel, monel metal, copper and nickel alloys; aluminum bronzes; manganese bronzes, cast and wrought; phosphor-bronze; muntz metal, naval brass, tobin bronze, brass (60 Cu + 40 Zn), yellow brass (70 Cu + 30 Zn); red brass; bearing metals; white metals, etc.

The collection of these data and other data that are expected from manufacturers should result in securing material that, when compiled and published, will be of value to manufacturers, metallurgists and all concerned with the making and use of alloys.

ELECTRIC RIVETING[1]

CONSTRUCTION AND OPERATION OF MACHINES FOR WELDING RIVETS

BY DOUGLAS T. HAMILTON[2]

ELECTRIC riveting is accomplished by a machine resembling the well-known spot welder, provided with a number of modifications to facilitate the setting of rivets. Electric riveting in its simplest form is done with two opposing copper electrodes, the center lines of which coincide. One of the electrodes—usually the upper—is movable vertically. The lower one is made to fit the head of the rivet and the upper one is made to the proper shape and size for upsetting the protruding end of the rivet.

Methods Employed in Electric Riveting

There are several methods of riveting in an electric welding machine, one of which is illustrated diagrammatically in Fig. 1,

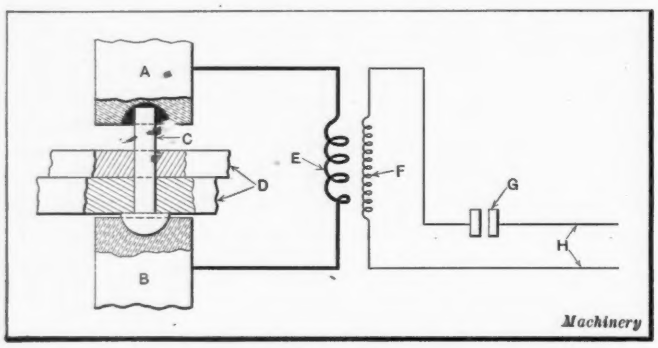


Fig. 1. Diagram illustrating Application of Electric Spot-welding Machine for Electric Riveting, showing Electrical Connections

in which A represents the upper movable copper electrode, and B the lower stationary electrode. C is the rivet, and D the plates to be riveted together. A and B are the terminals of the secondary winding E of the transformer, and F is the primary winding of the transformer, from which leads are brought out to connect to the lines, the switch G being interposed to make and break the circuit.

After the rivet is inserted through the plates and the stock is in position, as shown in Fig. 1, the electrode A is moved down lightly against the end of the rivet. The current is then turned on by closing switch G. The current induced in the secondary winding E flows directly through rivet C. This current is adjusted to such a pressure as to cause the rivet to become heated quickly. As soon as the proper temperature is reached, switch G is opened, cutting off the current, and at the same time a greatly increased pressure is applied to electrode A, which upsets the rivet and forms a head shaped like the recess in the electrode.

The heating of the rivet is done so rapidly that there is little loss by radiation or conduction. Therefore the plates D do not produce much chilling effect, and the rivet is heated throughout its length. For this reason, when increased pressure is applied to electrode A, the rivet is upset in the hole in plates D and fills the holes tightly. Even in the extreme case shown in Fig. 3, where there is considerable clearance between the rivet and hole, the hole is effectively filled by the rivet and a tight joint secured. The heating is done fast enough to prevent the formation of scale, which is always found on rivets heated in a forge fire, and the maximum strength is therefore insured. Further than this there is no overheating or burning of the rivet. Fig. 2 shows a rivet in the process of upsetting. Reference to this illustration will show that there is a gradual bulging and folding of the fibers. The use of an air hammer results in breaking up these fibers somewhat, and hence reduces the shearing strength of the rivet.

[1] For previous articles on electric welding published in MACHINERY, see "Electric Seam-welding," January, 1917, and articles there referred to.
[2] Address: Fellows Gear Shaper Co., Springfield, Vt.

Fig. 2. Sequence of Operations in upsetting a Rivet in Electric Welding Machine

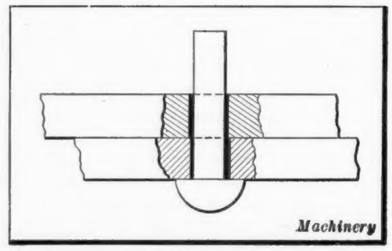


Fig. 3. Extreme Case of Difference in Size between Hole in Sheet and Diameter of Rivet—Electric Riveting effectively closes this Clearance Space

Modifications in Electrodes Necessary for Electric Riveting

Both upper and lower electrodes are made of copper when the rivet to be upset is quite small—say up to and including 5/8 inch diameter. When the rivet is larger than this, the pressure necessary to upset it is sufficient to destroy the upper electrode in a short time, if it is made of copper. On machines for upsetting large rivets, therefore, it is necessary to use a harder material, usually steel, for the upper die. Steel, however, becomes quite hot in carrying the current, which destroys its temper. To overcome this difficulty, machines of recent design carry two upper operating members, one a copper electrode for heating and the other a steel die for upsetting the rivet.

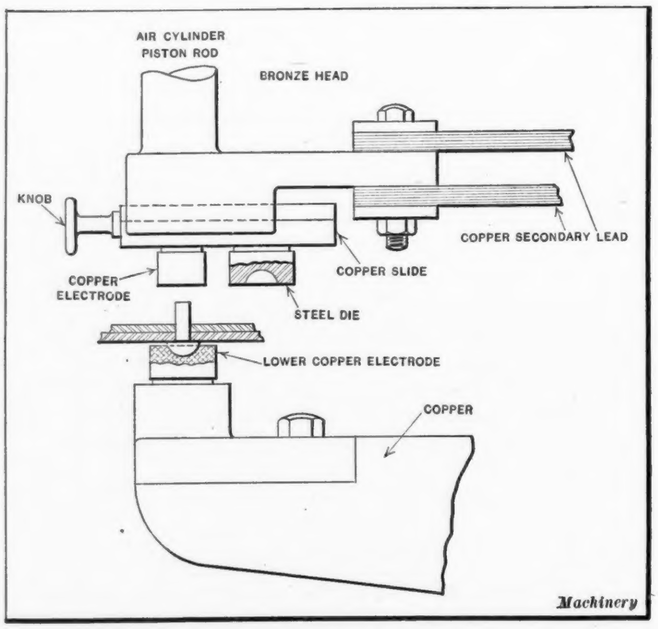


Fig. 4. Method of upsetting Rivets over 5/8 Inch Diameter, using Copper Electrodes for heating and Steel Die for upsetting

Fig. 4 illustrates diagrammatically the modifications necessary in an electric welding machine for upsetting large rivets. Here it will be noticed that the upper movable head carries a copper electrode and a steel die. These are held in a copper slide, which is pushed in or pulled back, depending on whether the rivet is to be heated or upset. Any suitable means can be employed for locating these two members in the desired position when in operation on the work. The copper electrode constitutes one terminal of the secondary circuit and serves to carry the current to the rivet. It is applied to the end of the rivet with just sufficient pressure to insure electrical contact. When this is done and the rivet has attained the proper temperature, the slide is withdrawn, bringing the steel die into position in line with the rivet, and then pressure is applied to upset the rivet.

Method of Upsetting Large Rivets

A simple means of operating an electric welding machine, and one that is frequently made use of for applying the two pressures—for electrical contact and for upsetting—is a cylinder supplied with compressed air. This is provided with a valve having three ports. One port connects directly to the air line and admits air into the cylinder at high pressure (60 to 80 pounds per square inch). The second port admits air at low pressure (5 to 20 pounds per square inch) to the cylinder. The low pressure is secured directly from the high-pressure piping by means of a suitable reducing valve. The third port in the valve allows the cylinder to exhaust and the steel upsetting die to return to its original high position. The valve is provided with a handle which moves in a horizontal plane through an angle of 90 degrees; this movement is sufficient to connect the cylinder with any one of the three ports. A small push-button switch *A* mounted on the valve handle *B*, Fig. 5, serves to control a remote solenoid switch for handling the welding current. Reference to Fig. 5 will show that the complete cycle of operations is taken care of by the right hand of the operator, which leaves the other hand free to handle the work. Inasmuch as all plants doing riveting use compressed air, the advantages of this type of machine are apparent.

When air pressure is not available or desirable, a machine may be driven by a belt or motor and employ the well-known punch press action. Electric riveters have also been built for manual operation or for a combination of manual and some sort of power operation, as shown in Fig. 6. In a machine of this type the left hand is used to bring the electrode lightly against the rivet and the current is controlled by thumb pressure on push-button *A*. When the temperature is right for upsetting, the right hand is used to turn the valve handle *B* to admit air under pressure to the cylinder.

Advantages of Electric Riveting

A number of machines are now in successful operation in this country which have shown quite a saving over the older methods of riveting and, in addition, make a tighter joint. In some cases one machine has taken the place of five men using air hammers. Except for the slight flash which results

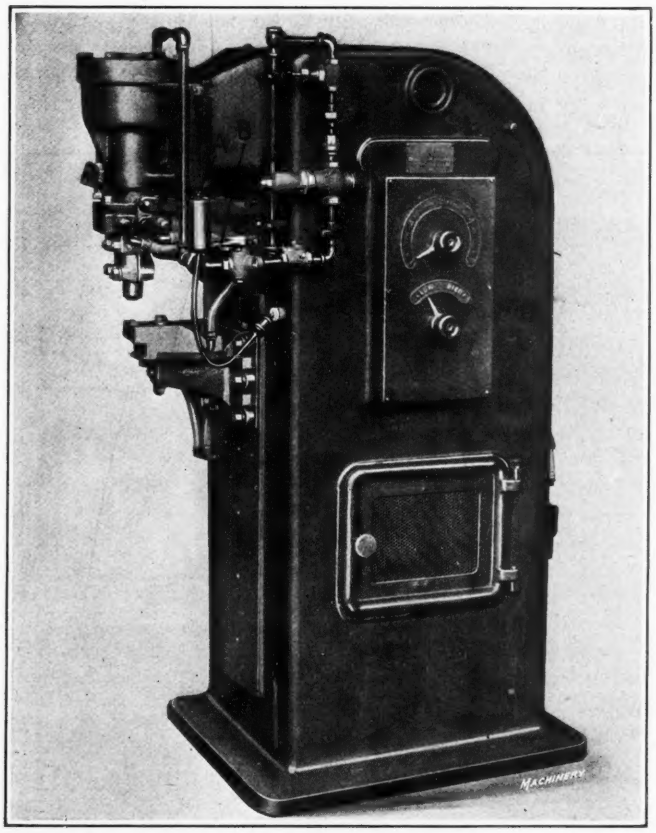


Fig. 5. Special Toledo Electric Welding Machine fitted with Air Cylinder and Three-port Valve for operating Electrode and Steel Riveting Die—Steel Riveting Die not shown in Position

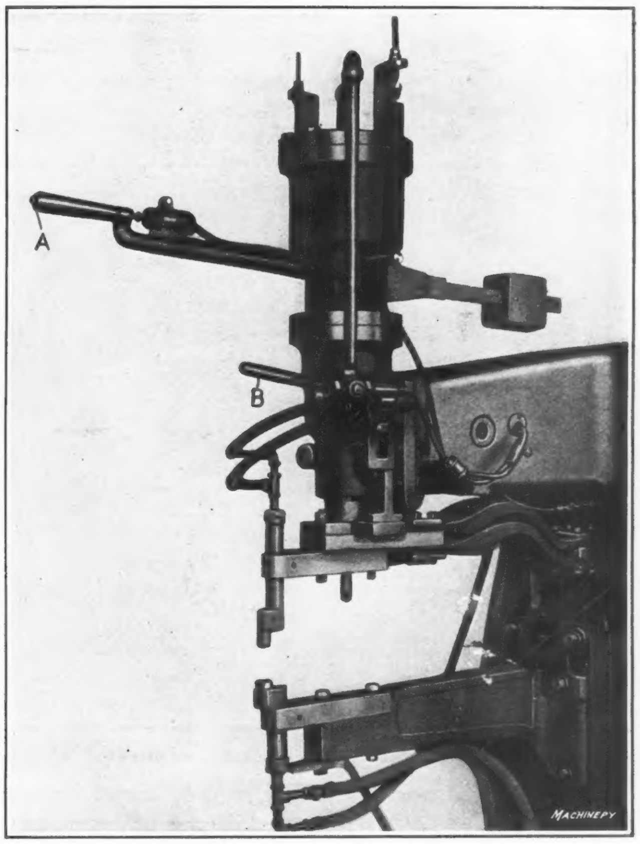


Fig. 6. Toledo No. 140 Type Electric Welding Machine fitted with Air Cylinder for Electric Riveting

when contact is made, electric welding machines make no noise or smoke and are quiet as compared with air hammers.

The actual time taken in one plant using these electric riveting machines for setting 5/16-inch rivets was 1½ second, and the electrical energy used, 15 kilowatts. This means 2400 rivets for 15 kilowatt-hours. At two cents per kilowatt-hour, the actual cost for current is thirty cents, or, roughly, one cent per 100 rivets. Variations in the size of rivets would cause a corresponding variation in these figures, but they serve to give some idea of the comparative cost. Electric riveting machines are now being used by automobile manufacturers for riveting the chassis frames, gear housings, differential and rear axle casings, and similar work. Gear rims are riveted to their spiders and structural arm sections are riveted together by this method.

* * *

In an article in *Industritidningen Norden* (Stockholm, Sweden), a review is given of the increased costs in the iron and steel industry in Sweden. The price of iron ore has trebled compared with the prices before the war, the higher cost of ore alone adding, in some cases, as much as $8 to the cost of a ton of pig iron. The price of charcoal—which is used in Sweden almost exclusively in the iron and steel industries—has increased to 250 per cent of what it was before the war. This increase adds $20 to the price of a ton of pig iron; nor can coal be substituted for charcoal in order to decrease costs, because coal, which cost from $5 to $5.50 per ton before the war, now costs from $17 to $20 a ton, and the quality is not as good as before the war. The same quality as was obtainable at the price quoted before the war would cost from $21 to $25 a ton. Coke has increased in price from $6.50 to from $17 to $18 a ton, and the quality is not as good. If compared on the basis of quality, the price is now from $22 to $25 a ton. Pig iron is now sold at from $95 to $105 a ton. Ferro-manganese used in steel production is three and one-half times as expensive as before the war. Firebrick has doubled in price. Nitric acid is eight times; sulphuric acid, five times; oils used for hardening and tempering, six times; and machine oils, three times as expensive as before the war. Tungsten has risen to $13.50 per pound. Rolled wrought iron is quoted at from $145 to $150 a ton, and open-hearth steel from $195 to $202 a ton.

GRIDLEY AUTOMATIC TURRET LATHE[1]

DESIGN, CONSTRUCTION, OPERATION, TOOL EQUIPMENT AND ATTACHMENTS

BY DOUGLAS T. HAMILTON[2]

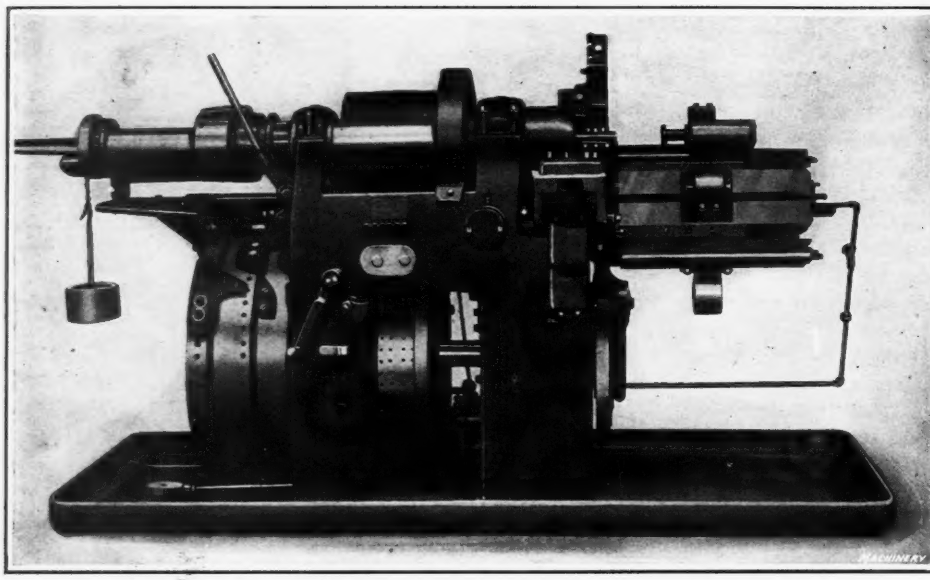


Fig. 1. Front View of Gridley Single-spindle Automatic Turret Lathe

GRIDLEY automatics are built in three types, namely, a single-spindle automatic turret lathe, a four-spindle automatic screw machine and a semi-automatic piston and piston ring machine. The original Gridley automatic, which was designed by G. O. Gridley in 1907, was of the single-spindle type, having a maximum capacity for bars up to 2⅛ inches in diameter. This machine met with such success that a multiple-spindle machine was designed and put on the market in 1908. With the exception of a few minor improvements in detail, these two machines are essentially the same today as when first put on the market. The piston and piston ring machine is patterned after the single-spindle automatic turret lathe, and differs from it chiefly in the design of the turret, which travels back and forth and does not index. It is also much simpler in construction and is not fully automatic in that it is necessary for the operator to insert and remove the work by hand. In the following article, attention will be directed chiefly to the design, construction, operation, tool equipment, etc., of the single-spindle automatic turret lathe.

Principles of Design

The chief point of interest in the design of the Gridley automatic turret lathe is the turret or tool-slide around which the machine is built. The turret is of practically square cross-section, the four surfaces being in a plane parallel to the axis of the spindle; on each face is a tool-slide for carrying the holders for the various cutting tools. This design makes it possible to support the tools close to the cutting point and completely obviates spring and consequent inaccuracy, which cannot be so easily overcome when the tool is held by a long shank in the turret, as is generally the case. This design of turret also permits one tool to be placed behind another, thus greatly increasing the range of the machine and particularly adapting it for handling work requiring the use of a greater number of end-working tools than there are tool-slides.

On the belt-driven type of machine, the spindle is driven by a belt through back-gears from the pulley shaft at the rear of the machine which carries three pulleys—two drivers and one loose pulley. In the majority of cases, both belts are arranged to drive the spindle in a forward direction, but one can be reversed to give a backward speed for threading, when desired. The turret drum carries four slides which are moved back and forth by means of cams on the large camshaft drum at the left-hand end of the machine; this movement is secured through a draw-bar which will be described later. The cross-slides are operated by cams on the drum at the right-hand end of the machine, the rear or cutting-off arm being operated on the rocking arm principle. The turret is indexed by means of a worm-wheel on the turret shaft, which is driven at a faster speed while the indexing is being accomplished; this is effected through a planetary gear mechanism which will be described in detail later.

Construction and Operation of Headstock

The headstock comprises a work-spindle *A*, Fig. 3, which rotates in two phosphor-bronze bearings, A_1 and A_2; the spindle is driven by gear A_3, attached to it by a key as shown, which receives power from a pinion on the pulley shaft at the rear of the machine. The pulley shaft carries three pulleys *B*, *C* and *D*. The two belts can be thrown alternately onto the idler pulley *C* when it is desired to rotate the spindle in either direction or at different speeds, or they can both be thrown onto the idler pulley when it is desired to stop the rotation

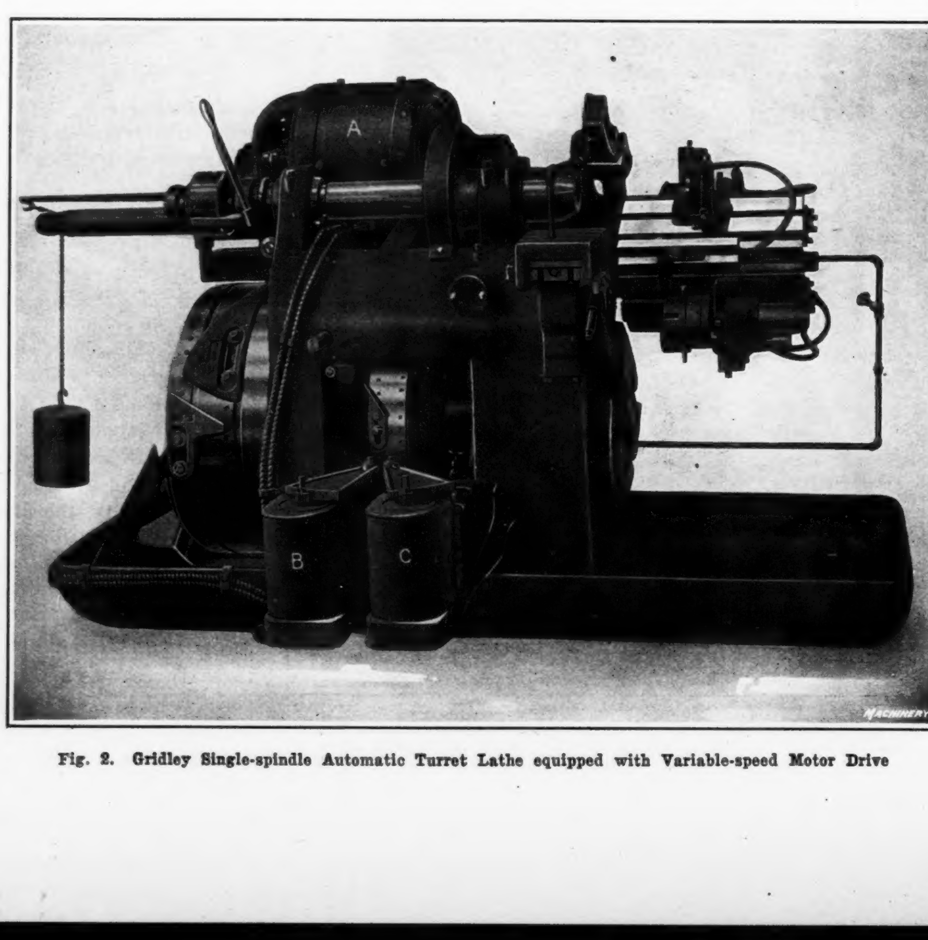


Fig. 2. Gridley Single-spindle Automatic Turret Lathe equipped with Variable-speed Motor Drive

[1] For information on automatic screw machine practice previously published in MACHINERY, see "Examples of Screw Machine Set-ups" in the November, 1914, number, and articles there referred to.

[2] Address: Fellows Gear Shaper Co., Springfield, Vt.

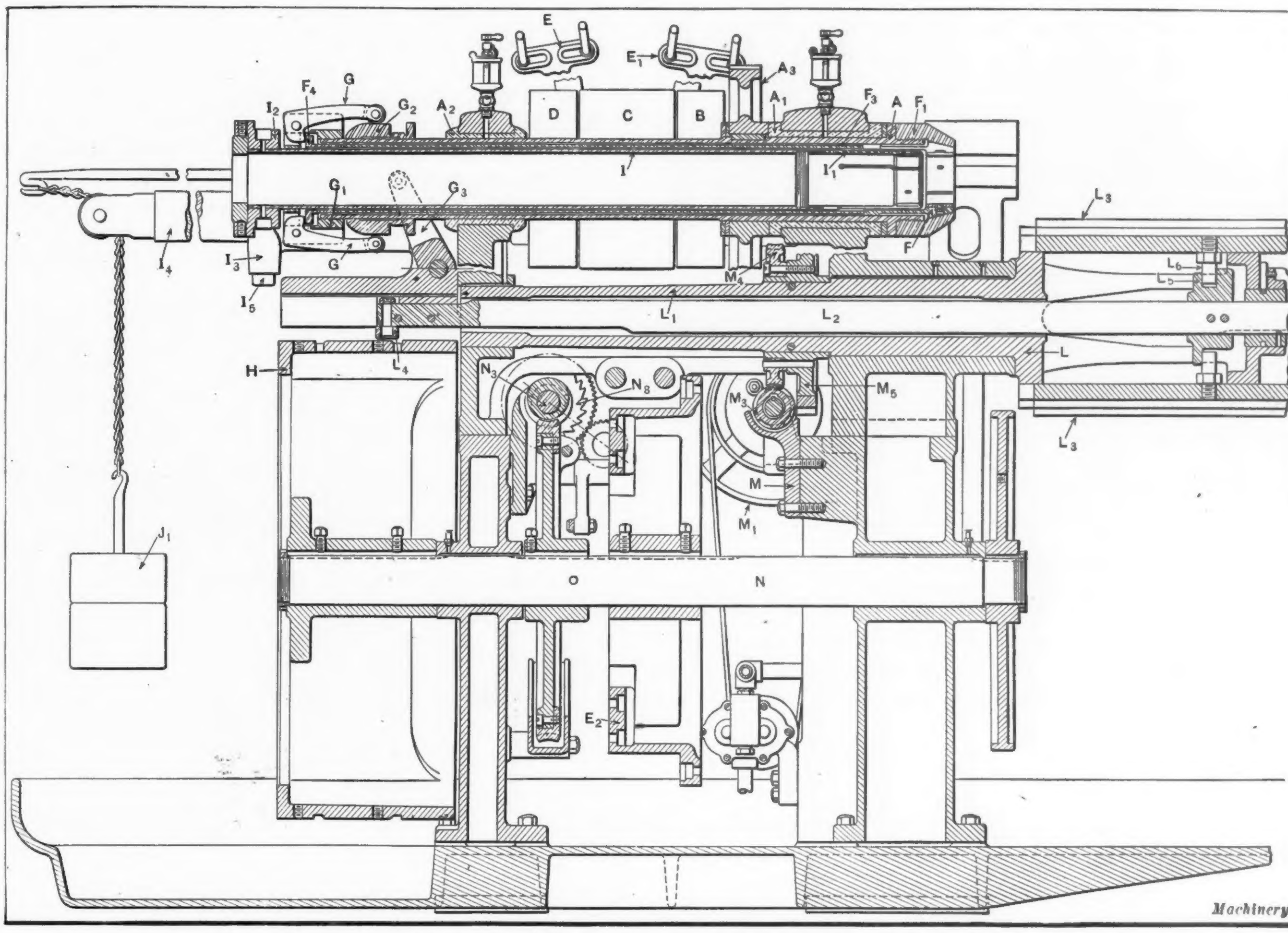


Fig. 3. Sectional View taken through Gridley Single-spindle Automatic Turret Lathe, showing Spindle Construction, Turret Construction and Operation of Main Cam-shaft. Note that Turret is swung around out of Correct Position to show Section

of the work-spindle. The belt shifting levers E and E_1 are controlled by dogs mounted on cam drum E_2.

Operation of Chuck-closing and Stock-feeding Mechanism

The bar stock being operated on is held in the spring collet or chuck F in spindle A and is closed by being forced into a nose cap F_1 that is screwed onto the nose of the spindle. The closing of the chuck on the stock is effected through the sleeve F_3 which bears against the rear end of the chuck and passes completely through the spindle of the machine. At the rear end of this sleeve is a flanged collar F_4, against which bear two fingers G. These fingers are fulcrumed in collar G_1, which is screwed onto the rear end of the spindle. The long arm of fingers G carries rollers running on sliding collar G_2, which is moved back and forth by the bellcrank lever G_3 carrying a roll on its lower arm that is operated by cams on the main cam drum H. This cam drum carries cam blocks K_1 and K_2, Fig. 5, cam K_1 withdrawing the collar from beneath the fingers and allowing the spring tension in the chuck to force the sleeve back and thus release the grip of the chuck

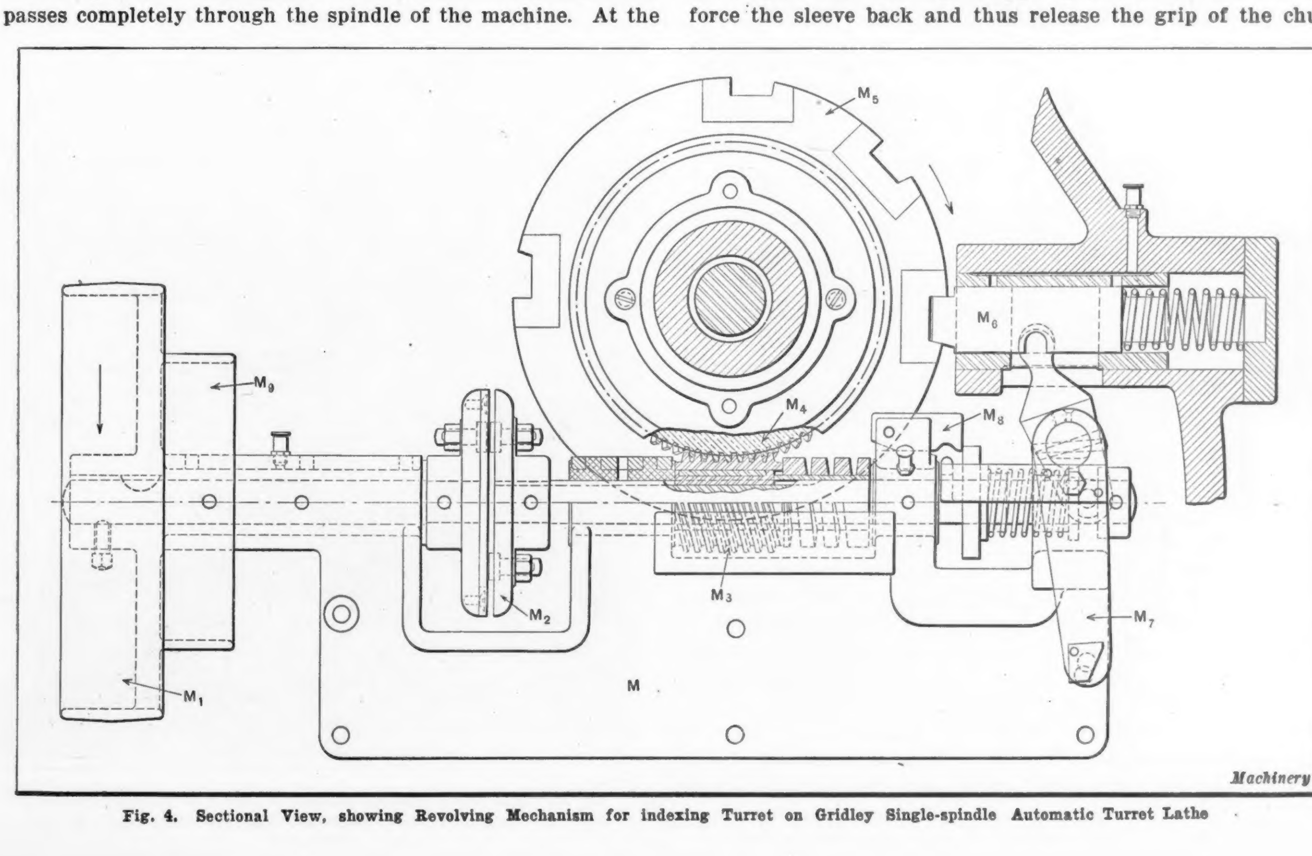


Fig. 4. Sectional View, showing Revolving Mechanism for indexing Turret on Gridley Single-spindle Automatic Turret Lathe

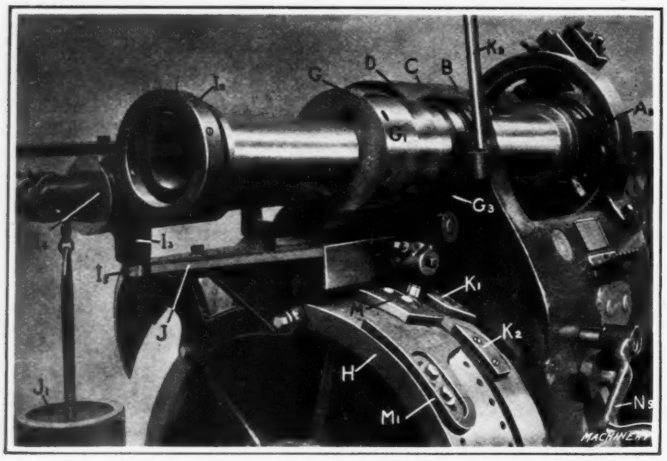


Fig. 5. End View of Gridley Single-spindle Automatic Turret Lathe, showing Cams for opening and closing Chuck and advancing Turret Slide, also Cams for operating Stock Pusher

on the work, whereas cam K_2 through bellcrank lever G_3 forces collar G_2 beneath the fingers, raising them up and, through the short arm of the fingers, forcing sleeve F_3 forward to close the chuck. Bellcrank lever G_3 has a hole in it in which an operating lever K_3 is inserted for opening and closing the chuck by hand when setting up the machine and adjusting the grip of the chuck on the work.

The feeding of the stock is accomplished by a combined weight and cam action. As shown in Fig. 3, a pusher or tube I carries at its front end a split chuck or pusher I_1, which has jaws suitably shaped for gripping the stock. The rear end of pusher tube I carries a collar I_2 in which a half yoke attached

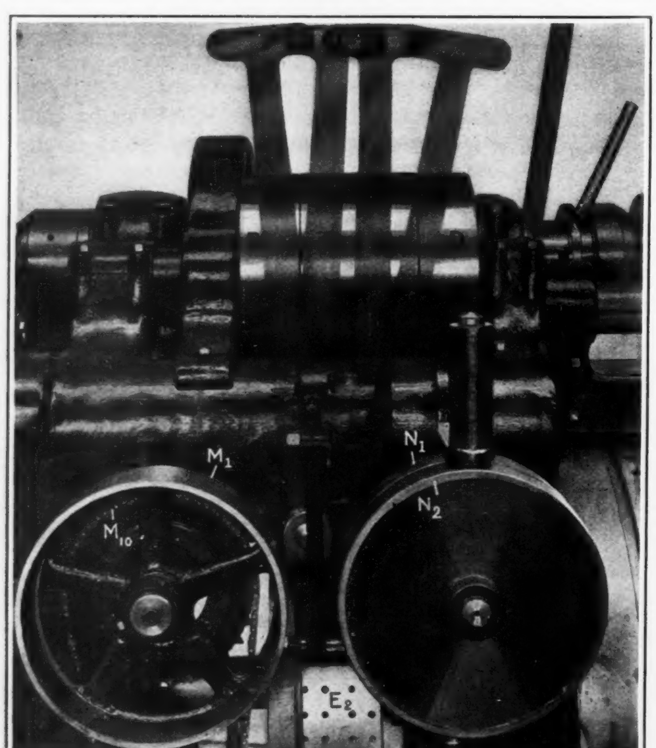


Fig. 6. Rear View, showing Drive for Main Cam-shaft and Indexing Mechanism

to bracket I_3 runs; bracket I_3, in turn, is free to slide on the bar-type bracket I_4. In action, cam J attached to cam drum H withdraws the pusher tube I so that the feed chuck I_1 is drawn back on the stock an amount equal to or slightly greater than the desired length of feed. Then when roll I_5 passes down the return side or incline of cam J, weight J_1, which has been lifted by the cam carries pusher I forward, and the chuck is opened. The feed chuck carries the stock forward until it contacts with the stop held on one corner of the turret, as will be described later. The feed chuck then remains in the forward position until cam J again comes into action to withdraw it.

Construction and Operation of Turret

The turret, as has been previously explained, is the feature about which this machine has been built. In construction, it comprises a square casting L, having an extended shank L_1 that passes through the machine and is supported in bearings located in both ends of the headstock. Passing through the center of this extended shank is a pull-rod L_2 for operating the four tool-slides L_3. This pull-rod carries a roll L_4 which is operated upon by cams on drum H. The turret drum L does not move back and forth, but is indexed to bring the various

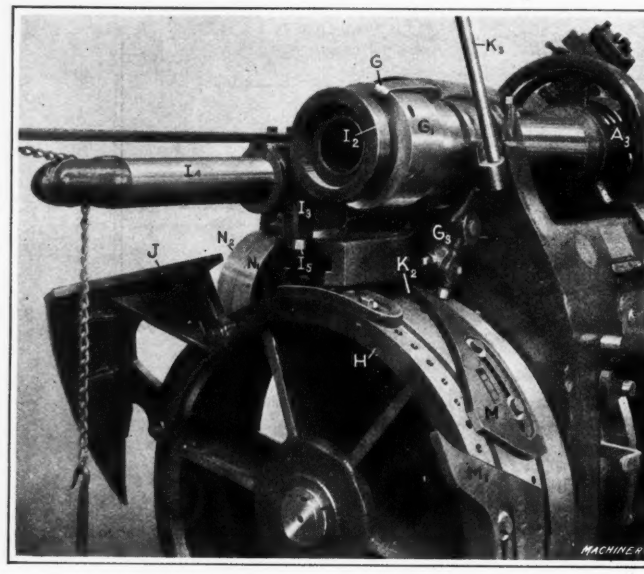


Fig. 7. Front End View of Gridley Single-spindle Automatic Turret Lathe, showing Stock-pusher Operating Cam out of Engagement with Operating Roll

tool-slides in line with the work, as will be subsequently explained. The tool-slides L_3 are operated by collar L_5 on rod L_2; there is a groove in the collar which is cut away, as shown, for the greater part of its circumference, the full part of the groove being in the position where the various tool-slides are to be advanced toward the chuck. This collar also returns the slides to their backward position. Each tool-slide,

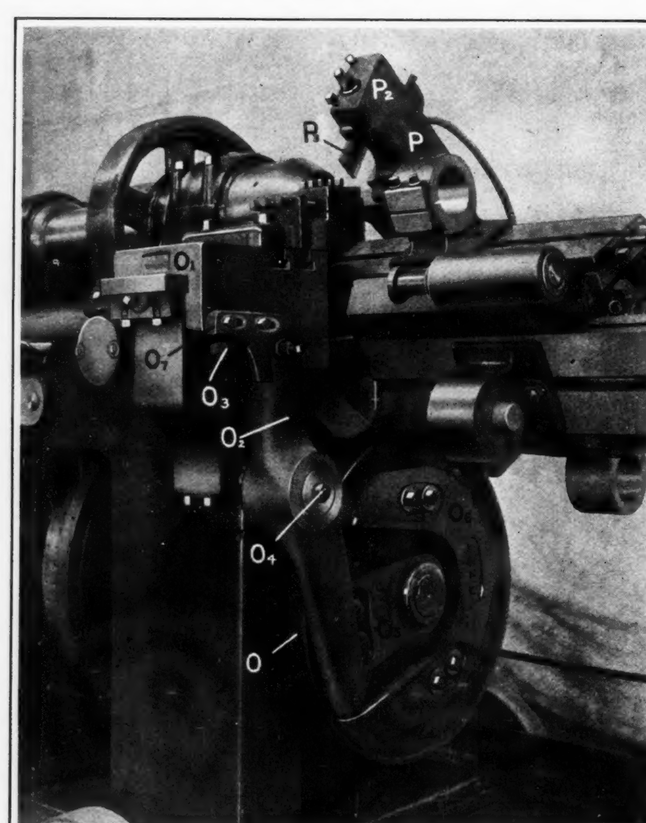


Fig. 8. Close View, showing Method of operating Forming Slide and Cutting-off Arm

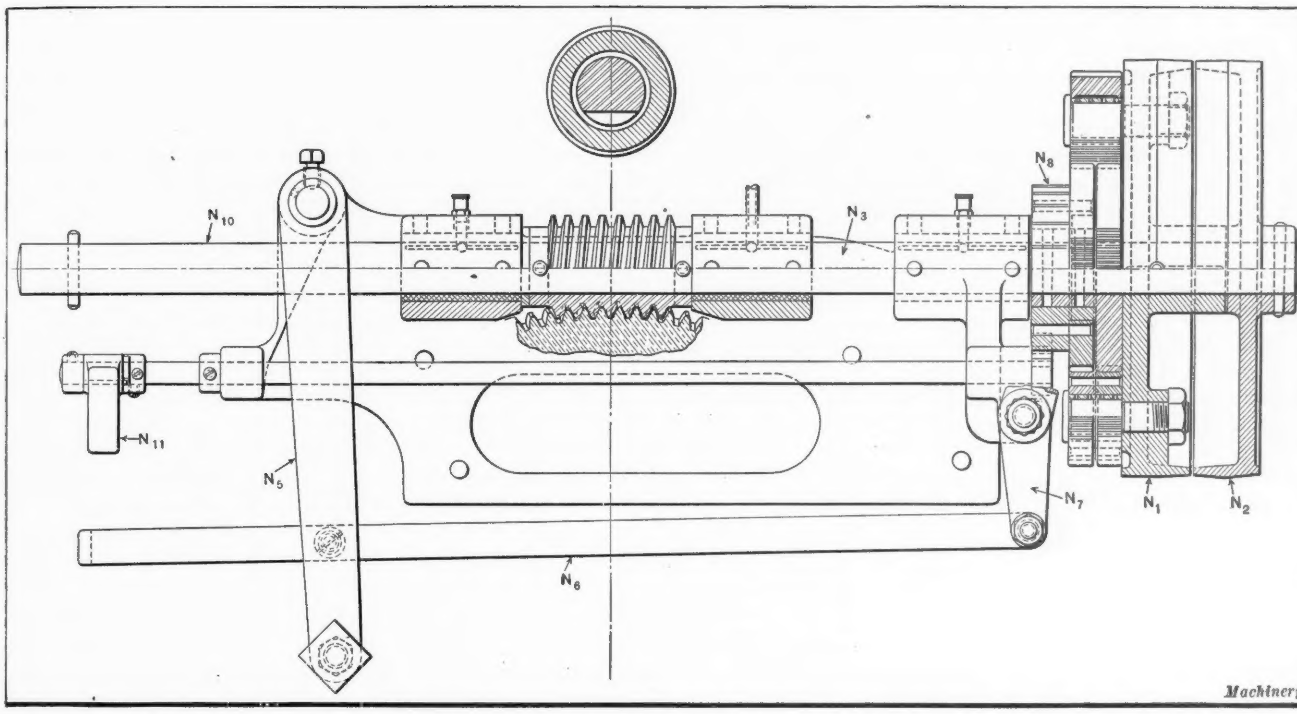


Fig. 9. Sectional View through Power Feed Bracket, showing Differential Gear Mechanism and Indexing Worm and Driving Worm and Worm-wheel

as shown, carries a roll L_6, which engages with the slot in collar L_5 when the turret has been indexed to bring the various slides into the operating position.

Pull-rod L_2 is operated by cams on drum H, a set of two cams being required for each turret position. Cam M advances the turret slide toward the work and cam M_1 returns the slide to its backward position. The turret tools, as shown in Fig. 1, are clamped directly to the faces of the slides, which are provided with T-slots for aligning purposes; these slides, as previously explained, are moved back and forth in gibbed grooves, in the four slide grooves in the turret. One corner of the turret is machined to receive the corner stop for limiting the feed of the stock.

Turret-indexing Mechanism

The indexing mechanism for the turret is operated by a separate belt from those used for driving the spindle and for rotating the main cam-shaft. Fig. 4 shows a sectional view taken through the indexing mechanism. Reference to this illustration will show that the indexing mechanism is carried on a separate bracket M and consists of a pulley M_1 which is belted to the countershaft, and through a friction clutch M_2 drives worm M_3; worm M_3, in turn, meshes with worm-wheel M_4, which is screwed and doweled to the index plate M_5, the latter being pinned to the extended shank L_1, Fig. 3, of the turret casting. Worm M_3 is also backed up by a stiff spiral spring as shown, which always keeps its teeth in

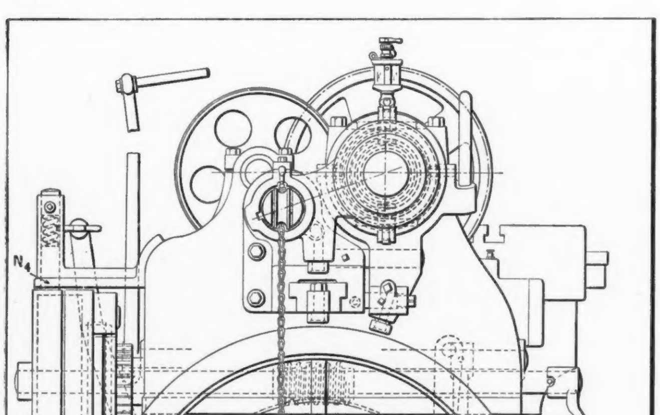


Fig. 10. Rear End View, showing Power Feed Mechanism and Main Cam Drum

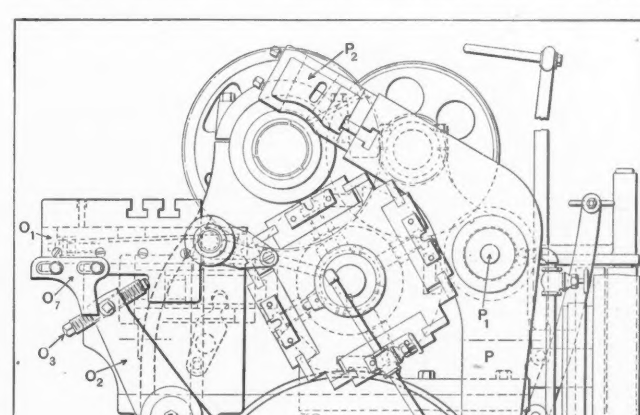


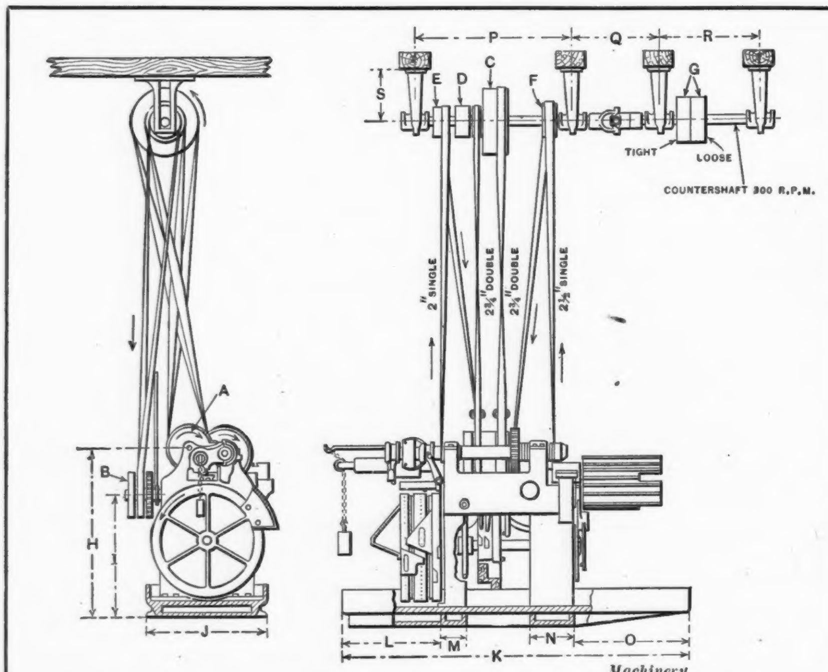
Fig. 11. Diagram illustrating Method of operating Forming Slide and Cutting-off Arm, also showing Construction of Turret and Turret Slide

accurate mesh with the indexing worm-wheel. The index plate M_8 is provided with five hardened blocks which act as locating stops for the locking pin M_6. These blocks are carefully hardened and ground and then set in place so that each indexing of the turret is accurately accomplished. The locking stop is also hardened and ground and is backed up with a stiff spring so as to keep it in constant contact with the turret index plate. It will be noted that, although there are five locating points in the index plate, there are only four turret faces. The fifth point is used for indexing for the stop held on one corner of the turret when all the other positions are full.

The operation of this indexing device is as follows: Upon the completion of the operation of any of the turret tools on the work and when the slide has receded far enough so that the tool clears the work, a dog set on cam drum E_2, Fig. 3, operates lever M_7, Fig. 4, and withdraws locking pin M_6 from contact with the block in the index plate M_8. At the same time trip M_9 is operated, allowing the spring on the friction shaft to come into play and engage friction disks M_3.

In order to eliminate the shock of quick engagement, these disks are provided with leather faces which engage before the driving blocks contact. When the lever M_7 leaves the indexing cam, locking pin M_6 is forced forward by the spring behind it, and at the same time a dog compresses the spring on the friction shaft, bringing the friction disks out of engagement and locking them by means of the trip previously mentioned. The indexing cams can be so placed on the drum that the turret can be made to skip one or more indexings if desired. The friction shaft continues to rotate the turret until the spring is compressed by the dog on the cam and lock M_8 falls into place. On the latest type of machine, pulley M_9 is replaced by a sprocket M_{10}, as shown in Fig. 6, for driving the oil pump.

TABLE 1. PRINCIPAL DIMENSIONS OF PULLEYS, COUNTERSHAFT, FLOOR PLAN, ETC.



Machine Size	Principal Dimensions of Pulleys, Floor Plan, Etc.							
	Pulleys							
	Pulley	A	B	C	D	E	F	G
2¼	Diameter, inches	11	12	18	8	8	9	12
	Width of face, inches	..	..	6	6	4	4	4
3¼	Diameter, inches	11	12	18	8	8	9	12
	Width of face, inches	..	..	6	6	4	4	4
4¼	Diameter, inches	11	12	15	10	6	9	15
	Width of face, inches	..	..	6	6	4	4	6

Principal Dimensions, Inches												
	H	I	J	K	L	M	N	O	P	Q	R	S
2¼	45	32	32½	93	25	7½	11½	34	41	22½	27	14½
3¼	45	32	32½	93	25	7½	11½	34	41	22	36¾	14½
4¼	50	32	32¾	104	35¼	7½	11½	34	41	22½	27	14½

Operation of Main Cam-shaft

The main cam-shaft N, Fig. 3, which runs the entire length of the machine and carries all the operating cams, is driven by a separate belt from the overhead countershaft. As shown in Fig. 6, the power feed is contained in a separate bracket which is located at right angles to the main cam-shaft. This bracket carries two pulleys N_1 and N_2; the former rotates the shaft N_3, Fig. 3, through planetary gears and reduces the speed for driving the cam-shaft at the "cutting" speed. Pulley N_2 drives shaft N_3 direct and at a fast speed for taking care of the idle movements, such as indexing the turret, returning and advancing the tool-slides to the cutting position, feeding the stock and closing the chuck. This action is accomplished by a plunger N_4, Fig. 10, which is normally kept in contact with pulley N_2 and prevents it from being driven direct by the belt which runs on both pulleys.

The change from fast to slow speed is accomplished through lever N_5, connecting-link N_6 and lever N_7, Fig. 9. When lever N_5 is tripped by a dog on the main cam-shaft, friction plunger N_4 is raised from contact with pulley N_2 and allows the belt to drive it direct. Then as this pulley is connected directly to the power feed shaft, it drives it direct, and so much faster than the planetary gears that the ratchet N_8 runs away from the pawl, thus rotating the shaft at a higher speed. When setting up the machine, the power feed shaft can be rotated by hand-lever N_9, Fig. 10, which is located directly on worm-shaft N_{10}. When it is desired to stop the rotation of the feed shaft, the feed-release clutch N_{11} is operated, thus lifting the pawl from contact with ratchet N_8, which results in breaking the connection between the planetary gears and the main feed shaft.

Operation of Forming and Cutting-off Slides

The forming and cutting-off slides are both operated from cam drum O, Fig. 8, on one side of which are placed the cams for operating the forming slide, and on the other side the cams for operating the cut-off slide. Reference to Figs. 8 and 11 will show that the forming slide O_1 is operated by a lever O_2 and adjusting screw O_3 that comes in contact with a projection on the lower face of the forming slide. Lever O_2 is fulcrumed at O_4, and on its lower end carries a roll which, as shown in Fig. 8, runs in the groove formed by the forming cam O_5 and the return cam O_6. The forming slide is returned by the lever O_2 coming in contact with bracket O_7 attached to the side of the slide. The upper part of the forming slide can be adjusted on the lower member by means of an adjusting screw, as shown, to bring the forming tool into the required relation to the work. The forming tools used on this machine, which are generally of the dovetail type, are held in a forming-tool holder that is fastened to the top face of the forming slide.

The cutting-off slide is in the form of a bellcrank lever P, which is fulcrumed on a stud P_1. The lower end of this lever

carries a roll that contacts with a cam on the inner side of cam drum *O;* whereas the upper end has a machined face in which there is a T-slot for carrying the tool-holder P_2. This tool-holder carries a blade type of cutting-off tool P_3. The tool-holder proper can be adjusted longitudinally in relation to the axis of the work to bring the cutting-off tool into the correct position, but for diameter adjustment it is necessary to move the blade in or out as required. One cutting-off cam generally covers a large range of work and can be used in all cases where it is not necessary to bring in the cutting-off tools more than once for the completion of a certain part.

Cams and Dogs

The main cam drum, located at the left-hand end of the main cam-shaft, carries cams for operating the closing and opening of the chuck, withdrawing the stock pusher or feed tube and operating the turret slide through the medium of the pull-bar previously mentioned. The cam drum located in the center of the machine, which is also mounted on the main cam-shaft, carries cams for shifting the belt, dogs held in the T-slot in its rim for indexing the turret and cams for moving the high-speed lever which operates the quick and slow movements of the cam-shaft.

The cam-shaft has a quick and slow movement in a ratio of 70 to 1. The cam drum held on the extreme right-hand end of the main cam-shaft carries cams having several angles for operating the cutting-off and forming tools. The cams for operating the turret have three angles, giving fine, medium and coarse feeds. These cams, as has been previously mentioned, are easily located on the drum and can be changed to the desired position. For special work, of course, the cams are cut to suit the conditions, as in some cases it is necessary to start with a fairly coarse feed and then gradually slow down when approaching the end of the cut, as in counterboring or facing operations.

Sizes of Gridley Single-spindle Turret Lathes

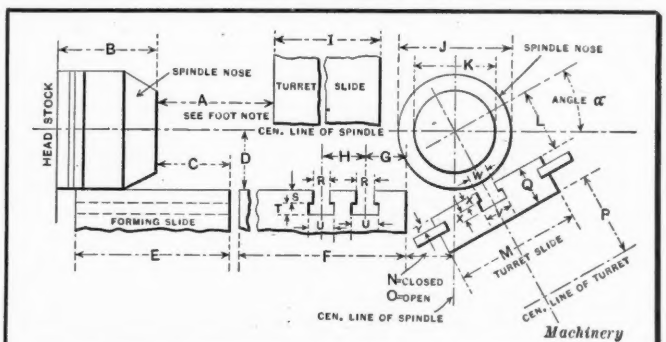
The Gridley single-spindle turret lathe is built in six sizes, which, rated according to the largest chuck capacities, are as follows: 1¼, 1¾, 2¼, 3¼, 4¼ and 5¼ inches. In all cases the feed of the turret slides is 12 inches. The spring collet or chuck, as well as the stock pusher or feeding finger, are provided with pads suitably shaped to accommodate the work being handled. These pads are hardened and are changed when a different size of bar is to be handled. The illustration accompanying Table 1 shows the belting arrangement on the belt-driven type of Gridley automatic turret lathe for the 2¼-, 3¼- and 4¼-inch sizes, and gives the principal dimensions, including sizes of overhead pulleys, floor plan, countershaft, etc.

The machine shown in Fig. 1 is a belt-driven machine. Fig. 2 shows the Gridley automatic turret lathe equipped with motor drive. When motor-driven, the machine is provided with two variable-speed motors, each having its own controller, resistance, etc. Motor *A* drives the work-spindle through the back-gears, and is provided with a controller *B* for producing the desired speed. The other motor, which is located at the rear of the machine and is geared to the power feed shaft, has a controller *C*. These two controllers are operated by cams located on the operating cam drum.

Table 2 includes all the tooling dimensions of the 2¼-, 3¼- and 4¼-inch sizes of Gridley single-spindle automatic turret lathes. These dimensions include the spindle nose, turret slide and forming slide and show the relation of the forming slide to the spindle nose and turret slide; referring to the illustration accompanying this table, it will be noticed that dimensions *N* and *O*, respectively, represent the relative positions of the forming slide when at its extreme forward and return strokes. These dimensions must be taken into consideration when designing special tools for use on the turret slide. The dimensions of the turret slide, of course, are necessary when laying out special types of turret tools, the distance on the various machines from the face of the turret slides to the center of the spindle being the same, or 4 inches.

Table 3 gives the principal dimensions of the cutting-off arm and its relation to the nose of the spindle; this arm brings the cutting-off blade in on an arc of a circle, instead of on a straight line in relation to the axis of the spindle. The top face of the arm, of course, does not always retain the same relative position in relation to the axis of the spindle, as shown in the illustration accompanying Table 3.

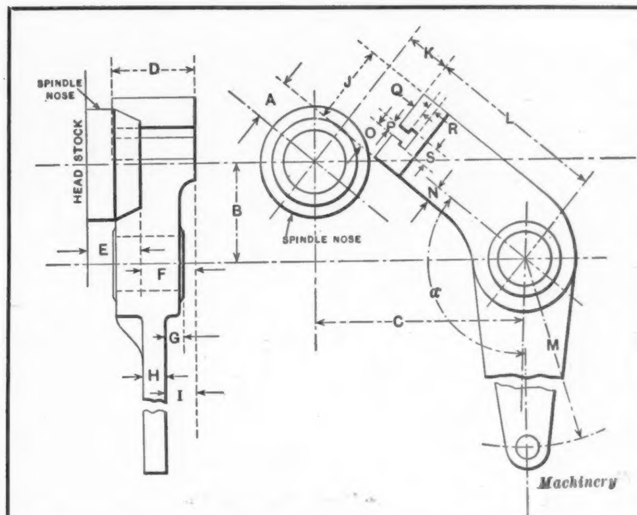
TABLE 2. TURRET SLIDES, FORMING SLIDE AND SPINDLE NOSE DIMENSIONS AND RESPECTIVE RELATIONS



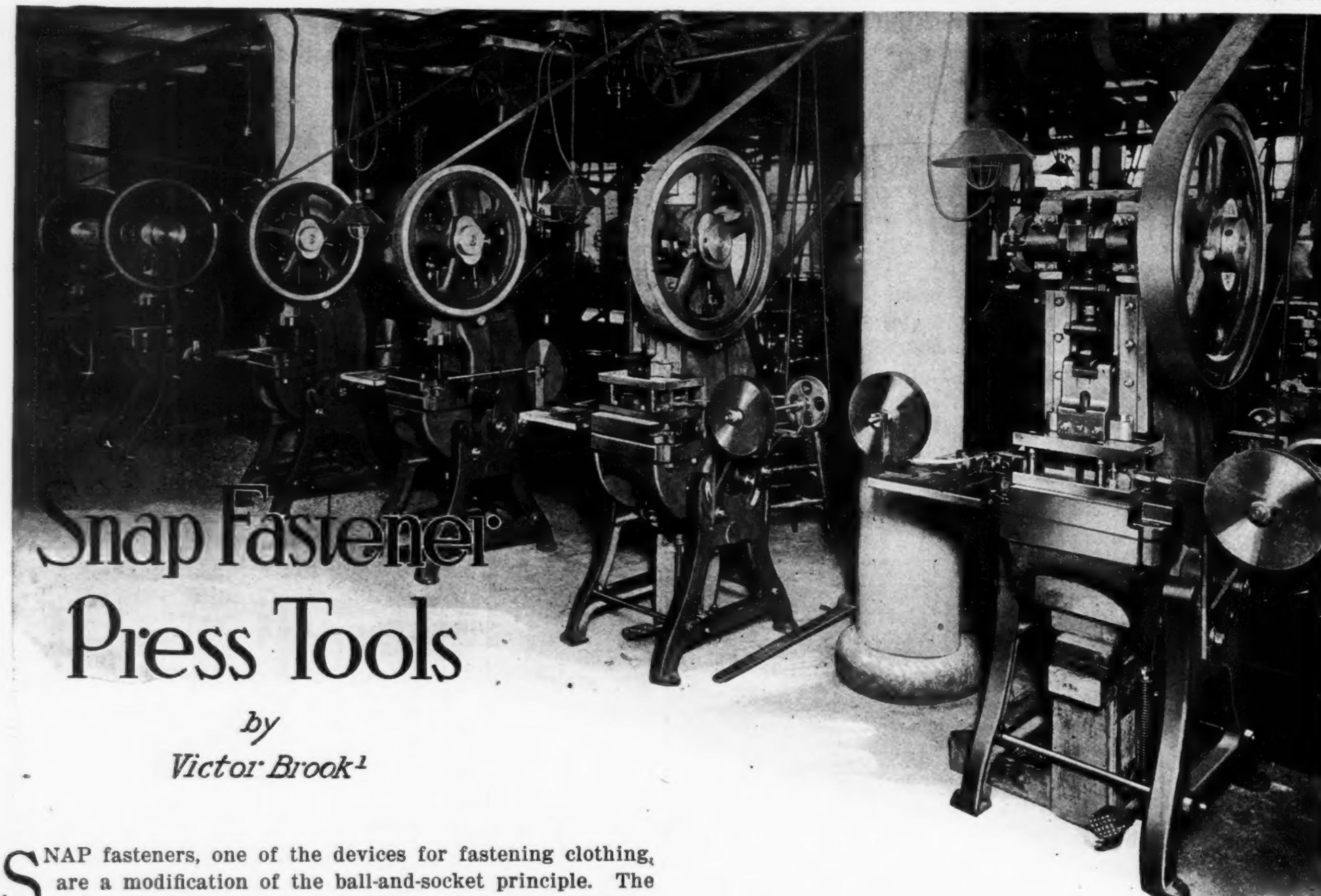
Dimensions, Inches	Rated Chuck Capacity of Machine, Inches			Dimensions, Inches	Rated Chuck Capacity of Machine, Inches		
	2¼	3¼	4¼		2¼	3¼	4¼
A	5⅛	5	5¼	N	2¼	2¼	2⅞
B	5⅛	5¼	5⅜	O	6	6	6½
C	3⅝	3½	4¼	P	4	4	4
D	2¾	3 5/16	5 3/16	Q	2	2	2
E	7½	7½	8¼	R	¾	¾	¾
F	10¼	10¼	10	S	⅝	⅝	⅝
G	2 1/16	2 1/16	2 1/16	T	½	½	½
H	2 1/16	2 1/16	2 1/16	U	1⅜	1⅜	1⅜
I	21	21	21	V	1⅜	1⅜	1⅜
J	5⅜	6⅞	7⅞	W	⅞	⅞	⅞
K	3⅞	5	5⅞	X	½	½	½
L	3	3½	4	Y	½	½	½
M	6	6	6	Angle α	29° 45′	28′ 10″	33° 7′

Dimension A gives the position of the tool-slide in the position it occupies when the turret is being revolved. The slide has a total movement of 8½ inches when using the regular cams.

TABLE 3. DIMENSIONS OF CUTTING-OFF ARM AND RELATION TO NOSE OF SPINDLE



Dimensions, Inches	Size of Machine, Inches			Dimensions, Inches	Size of Machine, Inches		
	2¼	3¼	4¼		2¼	3¼	4¼
A	1 9/32	1 13/32	2 13/16	K	3	3 11/16	3
B	6	6 9/16	6 9/16	L	11¼	11¼	12⅜
C	12.968	13½	14.463	M	18	18	18¼
D	5¾	5¾	5¾	N	⅝	⅝	1⅛
E	3½	3⅝	3¾	O	1½	1½	2
F	4⅛	4	3⅞	P	¾	¾	¾
G	1⅜	1⅜	1	Q	13/16	13/16	13/16
H	1¼	1¼	1½	R	½	½	½
I	2¼	2¼	2⅛	S	1⅜	1⅜	1⅜
J	4⅝	4⅝	5½	α	120°	120°	130°



Snap Fastener Press Tools

by
Victor Brook[1]

SNAP fasteners, one of the devices for fastening clothing, are a modification of the ball-and-socket principle. The fastener shown in Fig. 1 is known as the "Snyder" type. The tools for making this type of fastener are made by the Automat Tool Works, Inc., 252 Greenwich St., New York City. A set of press tools for making either the socket or the stud is practically a complete unit. Besides containing all the tools for the various steps required to complete the product, it also contains a roll feed, which is a part of the die unit. These tools are operated by a standard power press. The only special attachments are the reel for the stock and the power-operated scrap reel shown in Fig. 3. The power scrap reel, which is driven by a round belt from the lineshaft, takes up the scrap as it comes through the tool, but has no effect on the feed of the die. A complete set of tools will produce approximately 30,000 sockets or studs per hour. Four sockets are made at each stroke of the press, as the die is of the quadruple type.

All the working parts of these dies are small inserts, which are made interchangeable as far as possible, so that they can be replaced with the minimum loss of time. Besides, the various blocks for holding the dies, punches, etc., are made in short sections, so that an error in the construction of the die may be easily corrected. If the error cannot be corrected, a new block can be easily supplied without making any change in the remainder of the die.

Operations on Socket

There are nine operations on the socket. An assembly view of the punch and die for performing this work is shown in Fig. 5. Thirteen steps are shown in Fig. 6, but four of these are idle. A strip of metal in process of manufacture is shown in Fig. 2. In the first draw, the metal is drawn to the maximum depth and diameter. The dimensions of the punches and dies for the various operations are shown in Figs. 9 and 10. In the first redraw, the metal is reduced in diameter and depth and the radius at the bottom of the cup is greatly reduced. The exact reduction in the dimensions may be seen in the illustration by comparing the punches for the first draw and first redraw. In the second redraw, there is a slight reduction in diameter and depth, but the chief object of this operation is to harden the metal in the center of the socket, so as to give spring tension to the prongs, which are subsequently formed from this part of the material. The hardening is effected by crowning the punch. In the third redraw, the metal is hardened around the rim, and the socket is brought to the final depth. In addition, a sharp corner *a*, Fig. 6, is formed.

In the sixth operation, the star-shape is pierced; this makes a separation between the four prongs. In the seventh operation—embossing—the points of the four prongs are turned under. Between the eighth and ninth operations, Fig. 6, the strip is shown broken at b–b, to indicate that the views are turned through an angle of 45 degrees in order to make the construction clear.

In the ninth operation, the four sewing holes are pierced. The blank is not removed from the socket in this operation, but is simply bent against the wall. By this plan a smoother edge is given to the hole, and there is less probability of its cutting the thread when the socket is sewed on. The punch for this operation is of the built-up type, as can be seen in Fig. 10. In the eleventh operation—re-embossing—the prongs are bent to their final position.

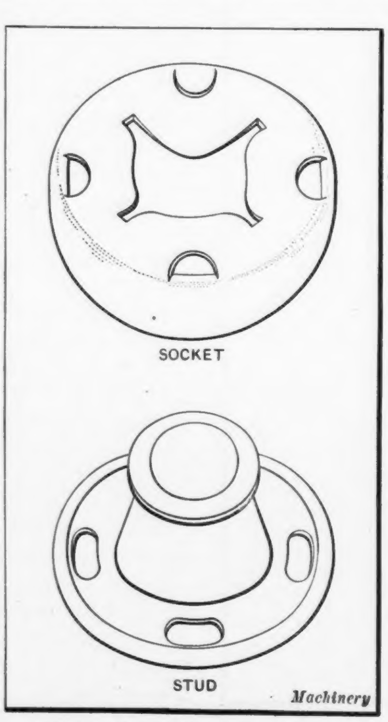


Fig. 1. Perspective View of Snap Fastener (Five Times Full Size)

[1]Associate Editor of MACHINERY.

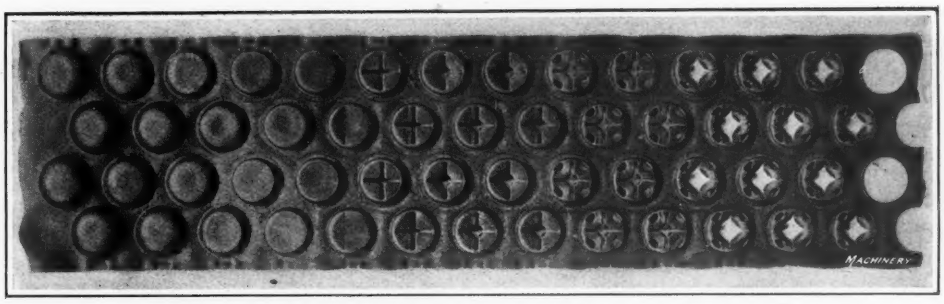


Fig. 2. Strip from Socket Dies showing Various Steps in Process of Manufacture

which is such that the stud will spring into the hole formed by the bent-under prongs, with just the correct tension. In the thirteenth operation, the completed socket is blanked from the metal strip.

Because of the condition of the socket at the time of blanking, it is not practicable to blank it in a downward direction. The punch is carried in the lower part of the die and the blanking die is mounted above. The finished work is ejected from the chute shown in Fig. 12. This chute is divided into two outlets, in order to bridge the strip of metal from which the sockets are being blanked.

Operations on Stud

There are nine operations on the stud, accomplished by the punch and die shown in Fig. 7. Fig. 8 shows twelve steps, but three of these are idle. A strip of metal showing the various operations is illustrated in Fig. 4. In the first draw, the metal is drawn to the maximum depth. The dimensions of the punches and dies for the various operations are shown in Figs. 13 and 14. In the second draw, the body is reduced in diameter and height, and the radius at the corner is decreased; the exact reduction may be found by comparing the dimensions of the first draw and first redraw punches and dies.

In the third draw, the body is reduced perceptibly in diameter and is given a slight taper. No attempt is made to reduce the height in this operation. In the fourth draw, the body is again reduced in diameter, but not in height. In the fifth draw, the upper part of the body is reduced in diameter and the sides are made perpendicular to the base. The sides of the lower half, however, form the frustum of a cone, which is the final shape. In the sixth operation, a head is formed; this produces a projecting rim of metal around the top of the stud. The lower part retains its conical shape because it is filled by the lower punch. In the eighth operation, the four sewing holes are pierced; these are oblong and are shown in detail in Fig. 14.

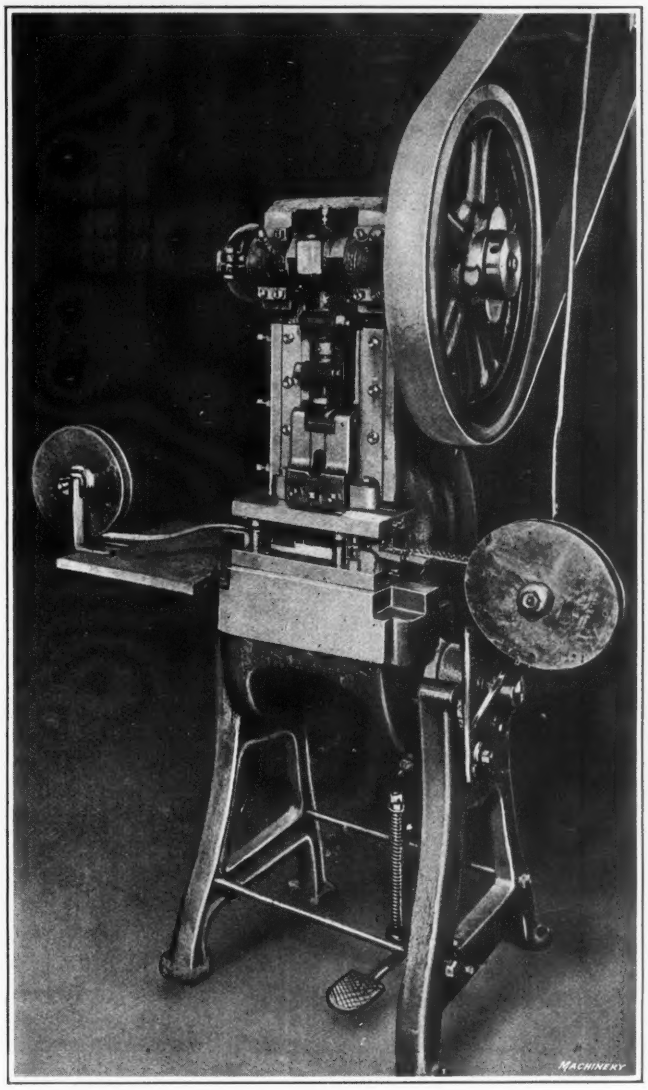


Fig. 3. Press Tools in Working Position on Press

In the tenth operation—embossing—a reinforcement is thrown up all around the outside rim of the stud. In the twelfth operation — blanking—the stud is pierced from the strip in a downward direction, the finished stud dropping directly through a hole in the lower die bolster. Operations seven, nine and eleven are idle, as previously mentioned.

Method of Feeding Strip

The method employed for gaging the advance of the strip for every stroke of the press is rather uncommon. Briefly, it consists in blanking off from the edge of the strip a narrow piece that is as long as the lead of the die. This is shown at *E*, Fig. 11. The punch, die and stop are shown in detail in Fig. 15, in which *a* is the punch, *b* the stop, and *c* the die. Punch *a* and stop *b* are carried by the upper member of the die. Stop *b* runs in the hole in die *c* and does not leave the die even when the ram of the press is in the "up" position. The strip is fed forward automatically by rolls *a*, Fig. 5. These rolls are moved part of a revolution at each stroke of the press and advance the strip approximately 0.01 inch more than the lead of the die, the extra amount being taken up in slippage. Rolls *a* are rotated by a pawl attached to rod *b* that engages with a ratchet on the roll. The feed may be varied by adjusting collars *c* up or down on rod *b*.

Method of Making Dies

The methods of constructing the dies for the stud and the socket are the same, so the method of making the socket die only will be described. This die is shown in Fig. 16. It consists of two main die-blocks *A* and *B* on which are mounted sectional strips that are bored out for punch-holders, die-holders and strippers. The strips, of course, are securely doweled to members *A* and *B*. The punch- and die-holding members are not hardened. The accuracy with which the holes are located in them governs the success of the entire tool, and thus presents a very fine toolmaking problem. The four

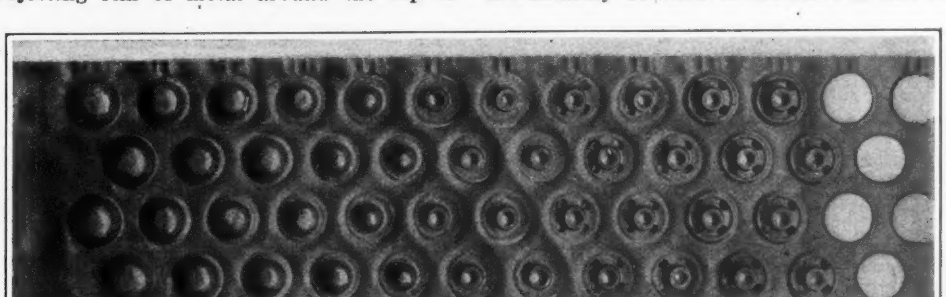


Fig. 4. Strip from Stud Dies showing Various Steps in Process of Manufacture

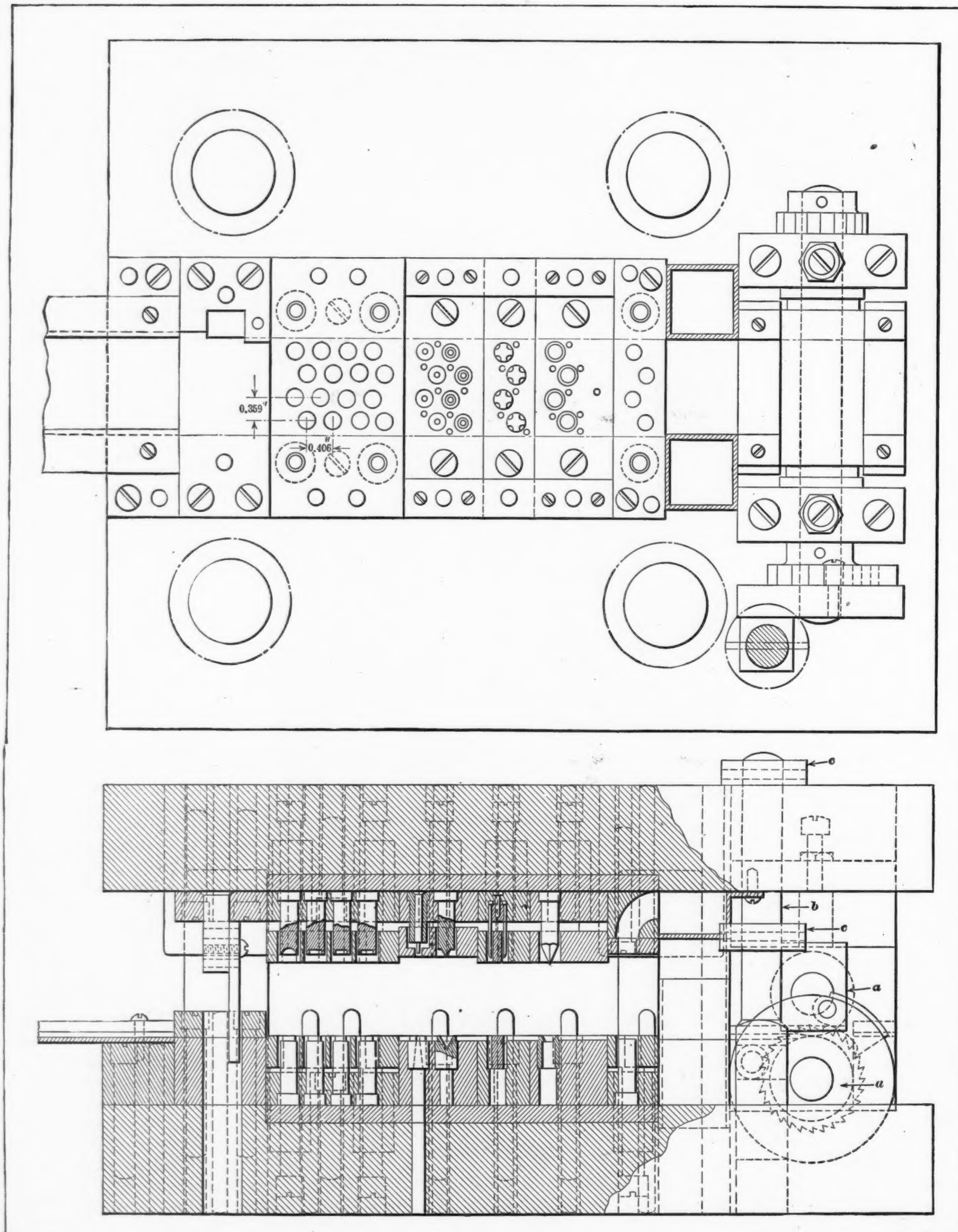


Fig. 5. Cross-sectional View of Punch and Die for Socket, and Plan View of Lower Member

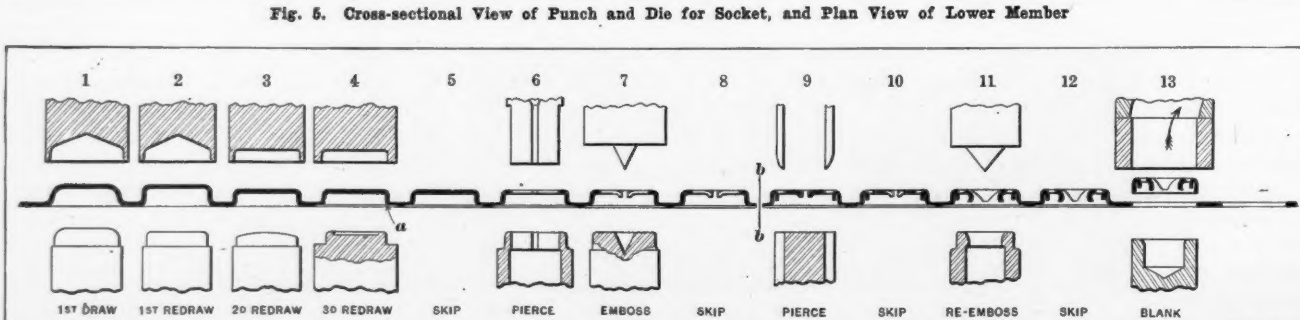


Fig. 6. Diagrammatic View of Upper and Lower Set of Tools and Strip, showing Progressive Steps in making Socket

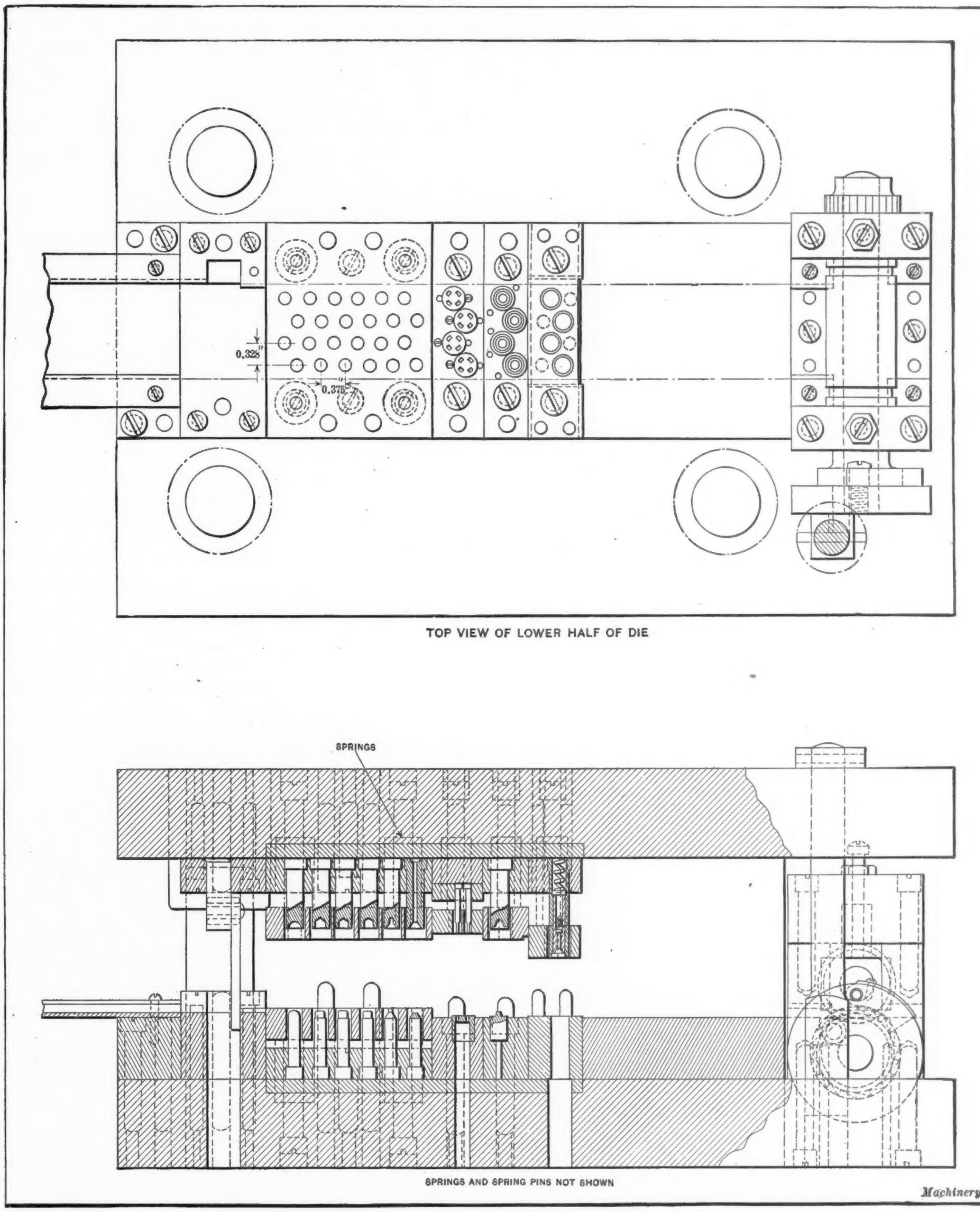


Fig. 7. Cross-sectional View of Punch and Die for Stud, and Plan View of Lower Member

posts of the die are fixed securely to B and run in bushings in A.

When making the die, blocks A and B are clamped together and the post holes a are drilled and accurately bored in line with each other. The accuracy of the center distances is not essential; it is simply necessary that the holes correspond in both blocks. Next, blocks c are clamped in the correct location on block B and the holes for the screws and dowels that are to hold the die-holders, punch-holders and strippers are drilled, reamed, tapped and counterbored. Previous to this, however, blocks c have been machined and ground all over except on the end. Die-block B is then mounted in an upright position on a horizontal milling machine and the thirty-six holes d are located. This is one of the most difficult and exacting jobs in the construction of the entire die, since these holes must bear an exact relation to one another in every direction. Rather than bore the holes entirely in the

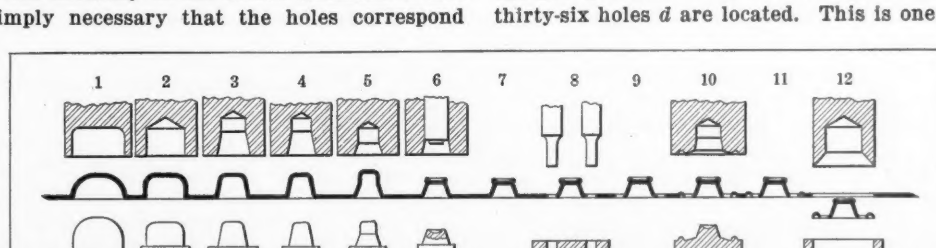


Fig. 8. View of Upper and Lower Set of Tools and Strip, showing Progressive Steps in making Stud

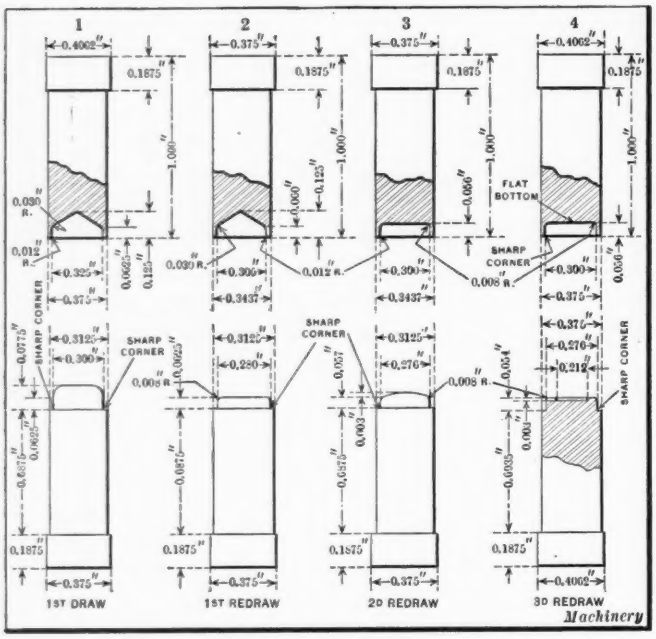


Fig. 9. Drawing Punches and Dies for Socket

milling machine, the position of each is accurately determined by a countersunk hole, approximately 3/16 inch in diameter at the large end. The tool used for this is an ordinary combination drill and countersink. Each block *c* is then removed and mounted individually on the faceplate of a bench lathe. Here they are accurately indicated from the countersunk holes, and the holes are drilled and bored and reamed to the required sizes. The dowel-holes *e* in blocks *b* are drilled and reamed by locating from blocks *c*, thus making the dowel-holes in the upper and lower blocks correspond. Blocks *b* are approximately 1/4 inch longer than blocks *c*, and when locating dowel-holes *e* this extra length is divided equally on each side, as shown at *A*, Fig. 11.

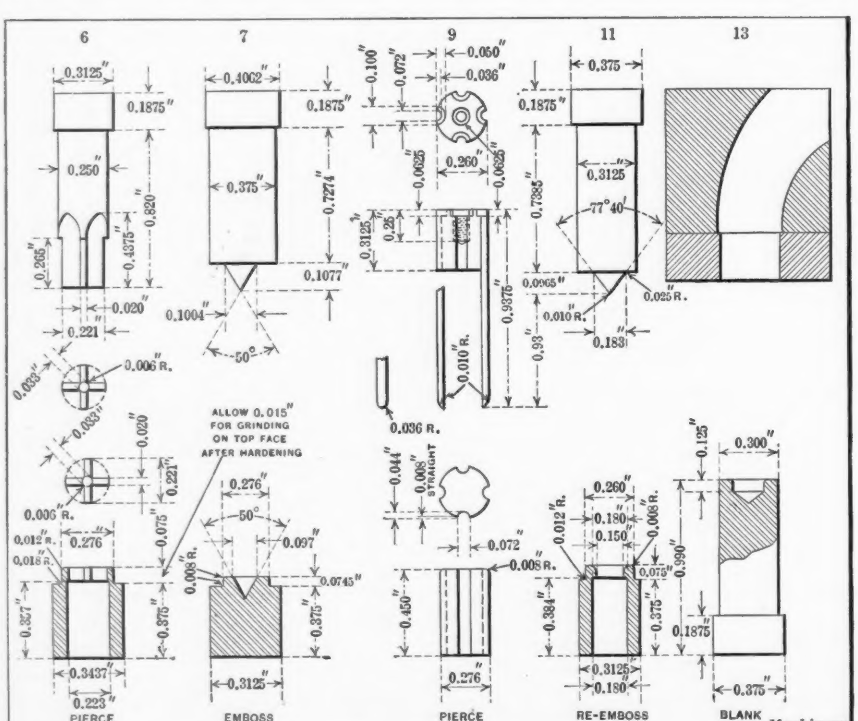


Fig. 10. Piercing, Embossing and Blanking Tools for Socket

After all the blocks *b* have been provided with dowel-pin holes, located from blocks *c*, they are held, one at a time, on a bench lathe faceplate, as indicated at *B*. The two blocks *b* and *c* are placed together, being accurately held by the dowel-pins *e*, and the various holes in block *c* are accurately indicated in block *b*. After each hole is centered, block *b* is clamped securely to the faceplate by the straps, block *c* is removed and the hole is drilled. This process is continued until the thirty-six holes have been transferred and drilled in blocks *b*. The extra length of *b* provides a surface for clamping it to the faceplate without interfering with block *c*.

The next step is to put in all the inserts, such as the punches and dies shown in Figs. 9, 10, 13 and 14. The piercing punches and dies, as may be seen in the views in Figs. 10 and 14, are adequately keyed to prevent turning while the die is in operation. The blocks *c*, Fig. 16, are then assembled on base *B*.

At the next step, the liner pins *a* and liner-pin bushings *f* are assembled, as illustrated at *C*, Fig. 11. Next, dowel-pins *e* are driven upward until they protrude a considerable distance above the surface of blocks *c*. Blocks *b* are placed on top of blocks *c*, locating from dowel-pins *e*. While in this position, the upper member *A*, Fig. 16, is slid down the liner pins *a* until it rests on blocks *b*. In this position blocks *b* are securely clamped to base *A*. Blocks *b* and base *A* are then taken to a machine where the necessary screw holes are drilled, tapped and counterbored, as illustrated at *D*, Fig. 11.

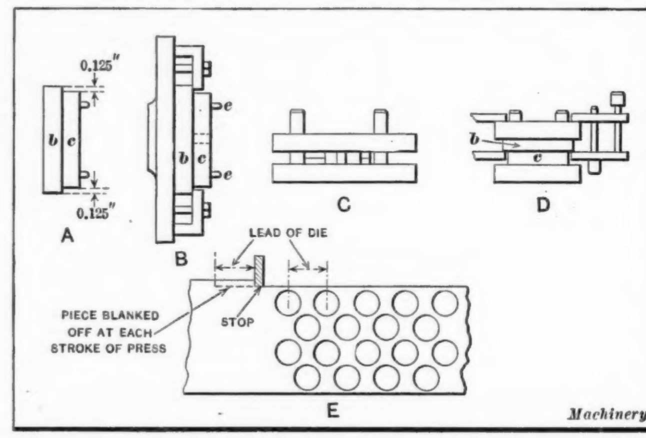


Fig. 11. Diagrams showing Steps in making Die, also Method of gaging Feed of Strip

After loosely screwing blocks *b* to base *A*, they are accurately aligned by the dies engaging with the punches in blocks *c*; blocks *b* are then tightened to die-block *A*. The alignment is carefully tested by working the two members *A* and *B* up and down on the posts *a*, verifying the alignment by entering dowel-pins *e* into the dowel-holes in blocks *b*. When the alignment is assured, the upper member is removed from liner pins *a*, the dowel-holes in blocks *b* are duplicated in the main member *A*, and the dowel-pins inserted.

Making Piercing Die for Stud

The piercing die for the stud has four oblong holes in it, equally spaced about a circle. As the piercing dies are made in duplicate, and as the holes are oblong, the prob-

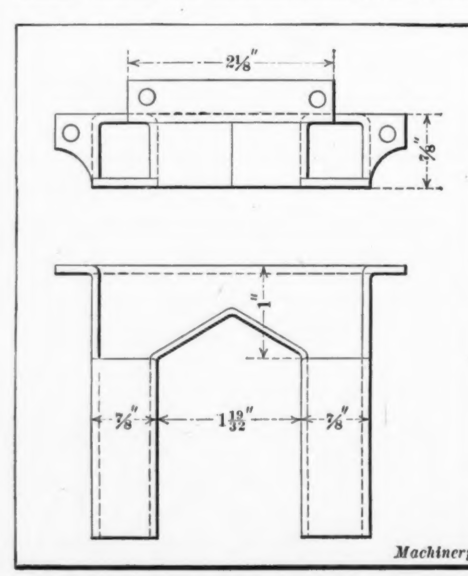


Fig. 12. Chute used on Socket Die for discharging Finished Parts

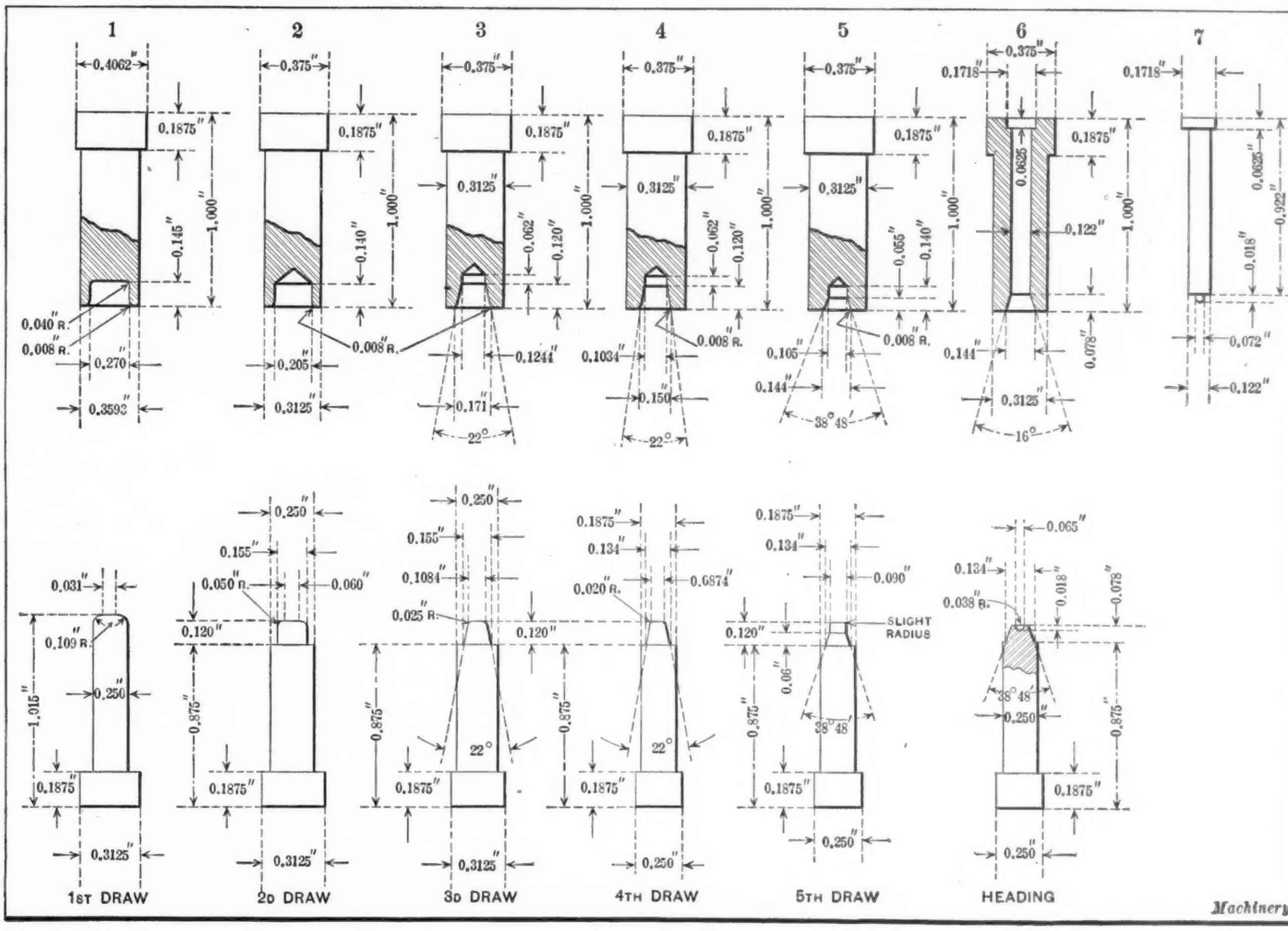


Fig. 13. Drawing and Heading Punches and Dies for Stud

lem presented is a rather difficult one. In addition, a semicircular keyhole must be formed in accurate relation to the other holes. With interchangeable dies and punches, it is a simple matter to replace a broken punch or die quickly, new parts being kept in stock.

For making these dies, the three broaches *e*, *f* and *g* and the fixture shown at *A*, Fig. 19, are used. The fixture consists of

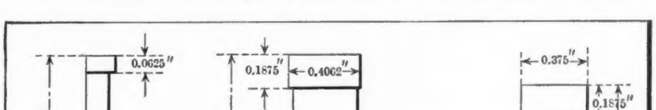


Fig. 14. Piercing, Embossing and Blanking Punches and Dies for Stud

a body *a*, a split ring *b* and two jig plates *c* and *d*. The entire fixture is hardened with the exception of the split ring *b*. The jig plates *c* and *d* are accurately and interchangeably doweled and screwed to the body *a*. In jig plate *c* there are five drilling holes, four of which give the location of the oblong holes, the fifth being used for drilling the keyhole in the die. The jig plate *d* has a square hole in it, the sides of which bear an accurate relation to the drilling holes in plate *c*.

When a die is to be made, it is placed in the slip ring *b*, which is held in the fixture by a set-screw. Then the five holes are drilled by the use of jig plate *c*. The keyhole is drilled partly in the die and partly in the split ring *b*; it is for this reason that the ring is left soft. After the ring has been drilled into all around its periphery, a new one is used.

Jig plate *c* is replaced by plate *d*, which is used to guide the three broaches *e*, *f* and *g*. Broach *e* is placed in one of the drilled holes and is gently tapped with a hammer. By repeating this for the four holes, the exact oblong impression is left on the face of the die. The broach *f*, which is of oblong shape, but approximately 0.003 inch smaller in size than the oval hole to be produced in the die, is located from jig plate *d*

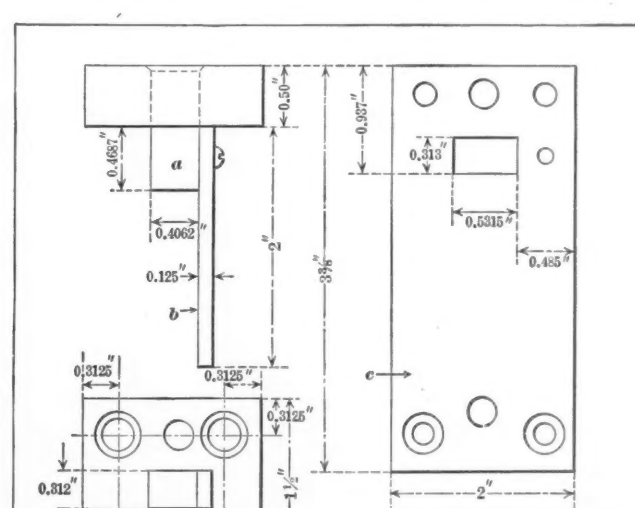


Fig. 15. Details of Die, Punch and Stop for gaging Advance of Strip

and driven into the die, removing the surplus stock. Then broach *g* is driven through the die, removing the small amount of material left by broach *f* and making the hole the correct size. When this work has been done on the four holes, the die is complete.

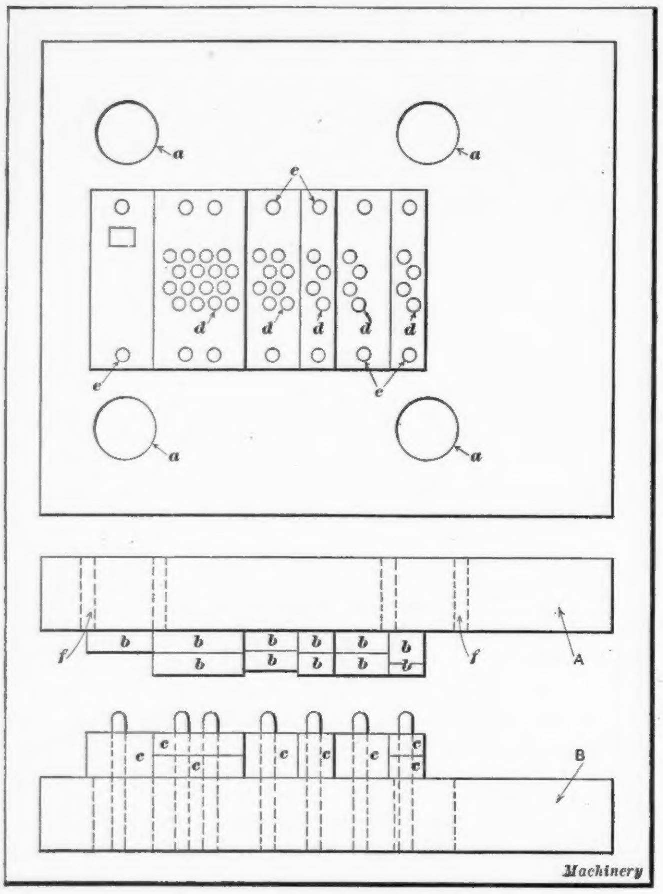


Fig. 16. Diagrammatic View illustrating Method of constructing Socket Die

Making Piercing Die for Socket

The making of the die for piercing the star-shape in the socket is also a difficult tookmaking problem, especially as these dies and punches are made in quantities, and have to be interchangeable. The star arms are only 0.02 inch wide,

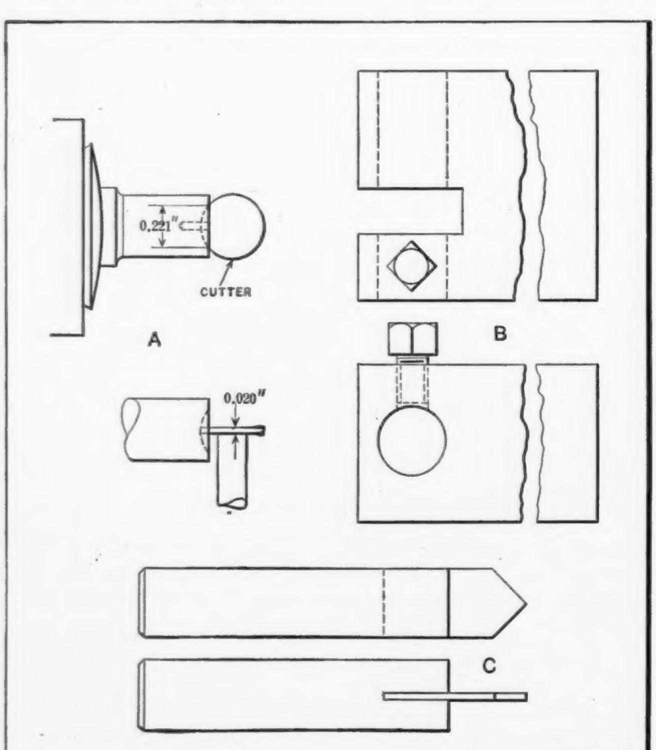


Fig. 17. Method of making Star Piercing Die for Socket

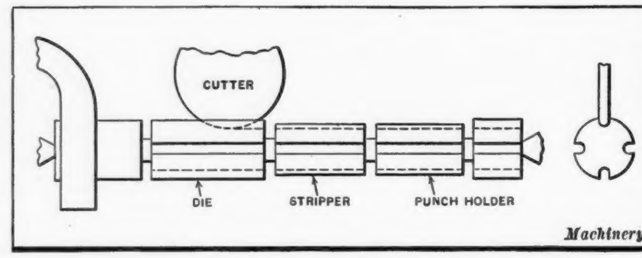


Fig. 18. Method of milling Die, Stripper and Punch-holder

so to finish them accurately by the ordinary toolmaking methods would be tedious and expensive. The following method was adopted and interchangeable dies were produced.

The stock from which the die is turned is held in the spring collet of a bench lathe and rough-turned. After this, a small hole is drilled exactly in the center of the die about 1/8 inch deep. Next, the bench lathe milling attachment is brought into position and, with a small milling cutter 0.020 inch in width centered accurately from the previously drilled hole, a cut 0.221 inch long is made in the face of the die. After this, the cutter is backed straight out and the work-spindle revolved 90 degrees, clamped into position, and the same milling operation repeated. This is illustrated at *A*, Fig. 17. After this milling operation, the die is turned on the outside diameter, cut off, turned around in the collet, and the back of the die is drilled out for clearance to within 0.075 inch of the face.

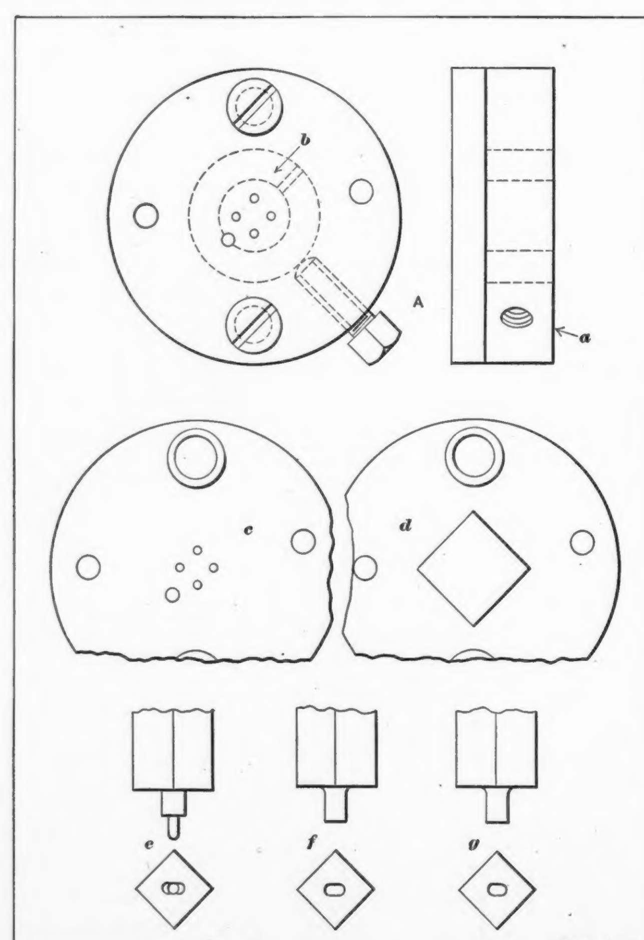


Fig. 19. Fixture and Broaches for making Piercing Dies for Stud

To complete the star-shaped hole, the inserted-blade broach *C* and the fixture *B* are used. The die is held in the lower part of the fixture and clamped by a set-screw. The broach *C* is located in the hole in the upper part of the fixture. The blade of the broach is guided into the face of the die by the previously milled slot and is driven through the die, first in one slot and then in the other, with a hammer. This completes the die except for smoothing the slot with a file, hardening and grinding the face.

The making of the punches is not so difficult. They are milled to size, using a simple dividing head and milling cutter, indexing four times. The dimensions for this punch and die are shown in Fig. 10.

Die, Stripper and Punch-holder for Socket

The punch-holder, die and stripper for the socket are similar in general construction and vary only in length and diameter. The distance from the center to the bottom of the semicircular slot is the same for all three parts. For this reason they are all turned out of one rod, and necked, as illustrated in Fig. 18; the semicircular slots are milled in the three pieces simultaneously. By this method interchangeability is readily obtained. This is, of course, essential in this case, as all three parts must work together and line up perfectly.

* * *

RAPID METAL SAWING

There is, perhaps, no class of shop work that is given so little consideration, as a rule, than the cutting off of bar stock and other material used in the machine shop. Because the operation is simple, it is often left to men who have no training whatever for the work, and is carried on in a slip-shod manner.

At the plant of the J. L. Mott Co., Trenton, N. J., a battery of five 21-inch special Lea-Simplex saws, built by the Earle Gear & Machine Co., has been installed; these saws are cutting off 1¾ inch diameter brass bars at an unprecedented rate. Each of the saws is equipped with a special clamp or vise for holding twenty-four bars at once. The bars are 5 feet, 6 inches long, and are cut into sixteen short lengths, requiring fifteen cuts. The time required for one cut through the twenty-four bars is approximately two minutes, forty-eight seconds, or seven seconds per bar. Two operators work on each machine, and helpers are provided to see that each of the machines is supplied with twenty-four bars to replace those being cut immediately after the fifteenth cut is finished. When the bars are first placed in the machine in the cutting position, they are securely clamped at the rear to a carriage which is moved forward by a screw and handwheel. By this means the twenty-four bars are advanced simultaneously after each cut to the next cutting position by simply turning the handle and advancing the rear carriage until the ends of the bars meet the gage-plate, which is set to gage four-inch lengths. Since the cutting time for each lot is less than three minutes, the operation is practically continuous and the two operators on each machine are kept busy. The entire operation of cutting up one load of twenty-four bars takes about forty-five minutes, and in the course of a ten-hour day one machine with two operators handles approximately 15,360 pounds of brass rods.

After one lot of bars has been cut, it is necessary to move the rear carriage backward about five feet to receive the next load. This would be a slow operation if it had to be accomplished with the screw and handwheel, so for this purpose the carriage is provided with a split nut engaging the screw, which may be released so that the carriage can be pushed back quickly by hand.

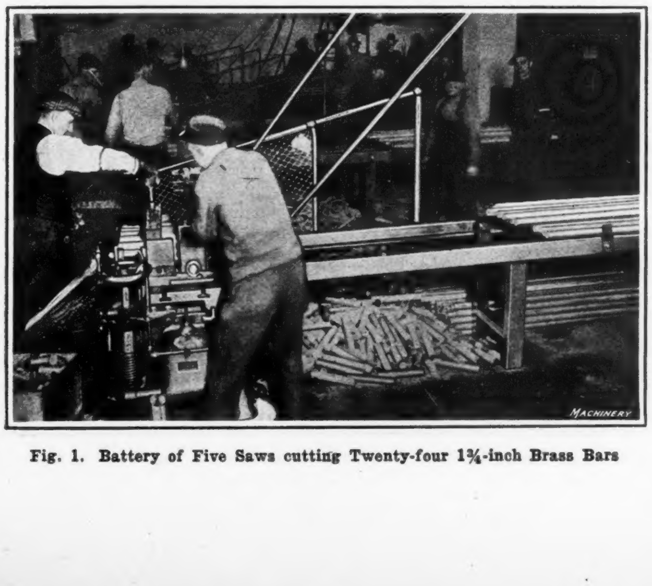


Fig. 1. Battery of Five Saws cutting Twenty-four 1¾-inch Brass Bars

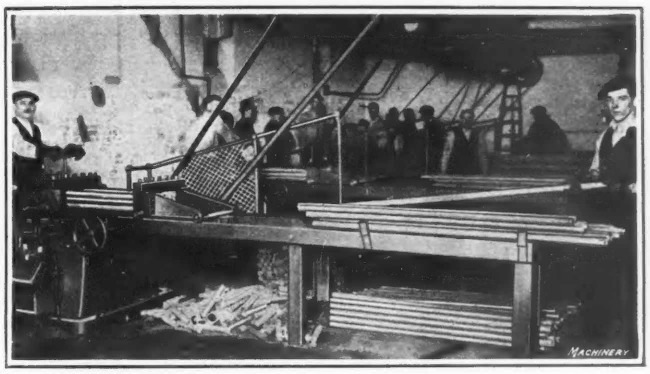


Fig. 2. Rear View, showing Carriage for holding Twenty-four Bars to be cut

The bars are stacked in eight rows, three high, and are held by clamping screws over each row. On account of the number of these screws, it seemed at first as though an air clamp might be more effective, but after the saws were in operation, it was found that the cut could be started as soon as the two screws over the bars first touched by the saw were tightened down and the rest of the screws could be tightened while the saw was cutting. This method of handling is so rapid that little time could be saved by the use of an air clamp.

A sheet-iron apron has been placed on each saw in front of the blade and above the limit of travel of the swing arm. This apron is sloping and allows the pieces that are cut off to roll down into boxes which are on wheels for convenient handling. A certain amount of the cutting compound flows down into these boxes, which have double bottoms and a spout to permit the compound to flow back into the base of the saw. The saw-blade expense has been about one cent per one hundred cuts, or one-twenty-four-hundredth cent per piece. V. B.

* * *

AMERICAN GEAR MANUFACTURERS' ASSOCIATION

An organization of gear manufacturers was formed at Lakewood, N. J., at a meeting held there March 25-27, that will be known as the American Gear Manufacturers' Association. Its purposes are to advance and improve the gear industry in a general way by standardizing gear design, manufacture and application. The association includes in its membership the foremost and better known manufacturers of gears. The executive committee is composed of the following: F. W. Sinram, Van Dorn & Dutton Co., Cleveland, Ohio; H. E. Eberhardt, Newark Gear Cutting Machine Co., Newark, N. J.; F. D. Hamlin, Earle Gear & Machine Co., Philadelphia, Pa.; Frank Horsburgh, Horsburgh & Scott, Cleveland, Ohio; Biddle Arthur, Simonds Mfg. Co., Pittsburg, Pa.; George L. Markland, Philadelphia Gear Works, Philadelphia, Pa.; Milton Rupert, R. D. Nuttall Co., Pittsburg, Pa. The following officers were elected at the Lakewood meeting: president, F. W. Sinram; vice-president, H. E. Eberhardt; secretary, F. D. Hamlin; treasurer, Frank Horsburgh. The next meeting of the association will be held at Pittsburg, May 14-15.

* * *

A "PROTECTED" LABOR MARKET

A high protectionist only could have written a letter containing the following gem:

> We don't believe in trade papers conducting a "Help Wanted" bureau. If it is done, it should be carried on separately, and the advertisements should not be found in with the regular issues. We have found by experience it is bad practice to let trade papers come to any of our offices, on account of these advertisements; it generally results in loss of help. The advertisements for help wanted could be printed on sheets and sent to the manufacturers, dealers, merchants, etc., separately.

In short, this manufacturer would deny to his workmen opportunity to change their jobs and perhaps improve their condition while he would give manufacturers and employers opportunity to hire men who have advertised. Why should the initiative be lodged with the employer as regards response to advertisements? Is it always right for employers to seek new employes and wrong for employes to seek new employers?

DIE-FORGING TROUBLES—2[1]

FORGING FORKED BARS WITH HEAVY BOSSES, CROSSHEADS AND EYE-PLATES

BY JOSEPH HORNER

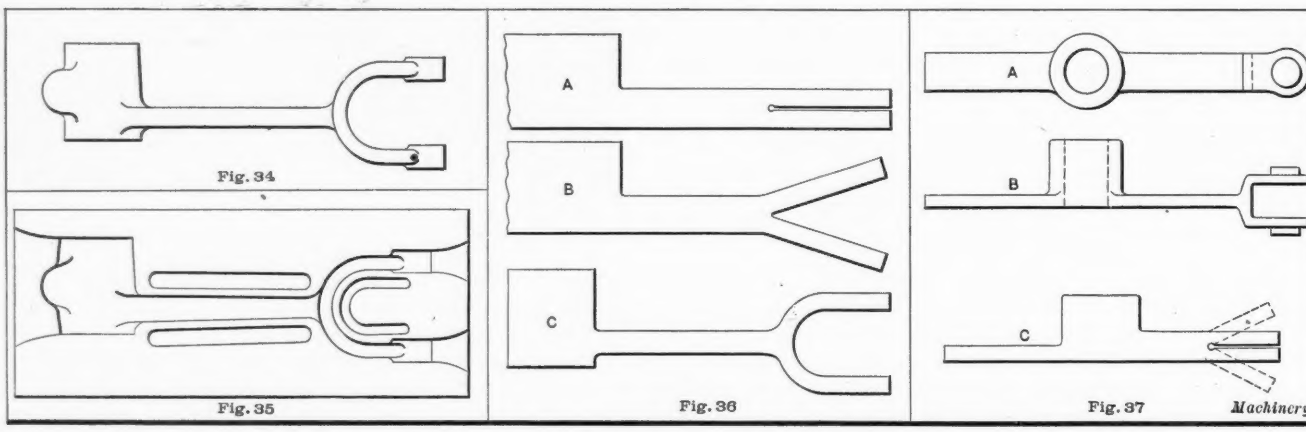


Fig. 34. Forked Bar with Heavy Boss on End
Fig. 35. Die for forging Bar in Fig. 34

Fig 36. Preliminary Stages in forging Bar in Fig. 34

Fig. 37. Forked Bar with Heavy Boss in Center

THE lever shown in Fig. 34 has a heavy boss extending from a slender stem at one end, and a widely spreading fork at the opposite end. This lever can be dummied down from a cubical lump in steel, but that would set up strains in the metal, besides imposing severe work on the dies. Such work is not profitable, because both dummying and stripping dies are required. The better method is to follow generally the same lines as the smith would adopt when forging in iron. A bar having a cross-section about equal to that of the boss should be drawn down under the hammer to the form shown at *A*, Fig. 36. The reduction is made on one side, as shown, until the thickness equals that of the two forks. That end is then divided with a hot set, opened out as at *B*, and curved over a form block. The stem portion is then reduced and drawn out until the forging has the rough form shown at *C*. It is finished in the die shown in Fig. 35. As it has been prepared roughly to outline, one pair of dies will suffice for finishing. There will not be much fin, and what there is may be expelled by sloping the die faces away from the edges of the impressions for the forging, by making a shallow gutter around the impressions, or by sloping channels away from the ends, as shown. The hole in the boss may be punched subsequently or drilled.

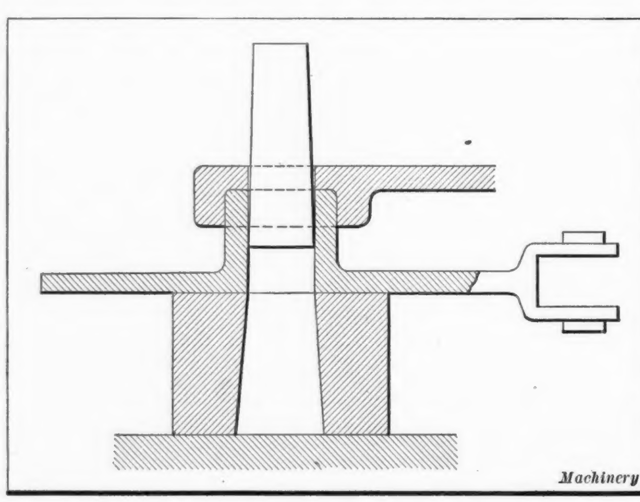


Fig. 38. Punching Hole in Boss of Bar in Fig. 37

The lever shown at *A* and *B*, Fig. 37, is similar to that shown in Fig. 34 as regards the difference in adjacent dimensions. Properly, it should be forged of steel by a method not very different from that which must be adopted if it is made of iron; this is indicated at *C*. A lump or a bar about equal in cross-section to the boss is reduced to a thickness and width roughly equal to that of the web, at the left hand, and at the right, to a thickness equal to that of the two prongs of the fork, with a width corresponding to the diameter of the bosses of the fork. Then the end is punched, divided and opened out as shown. The ends are bent roughly over a former, and the dies, Fig. 41, finish the outlines.

Two sets of dies are shown, between which there is little to choose, the jointing of one pair being at right angles with that of the other. In the one shown at *A*, which may be preferred, the flat of the web lies in the joint faces, with the deep boss standing up in the top die. This necessitates fitting the loose block *B* as a former on which to mold the forked end.

[1] The first installment appeared in the March number.

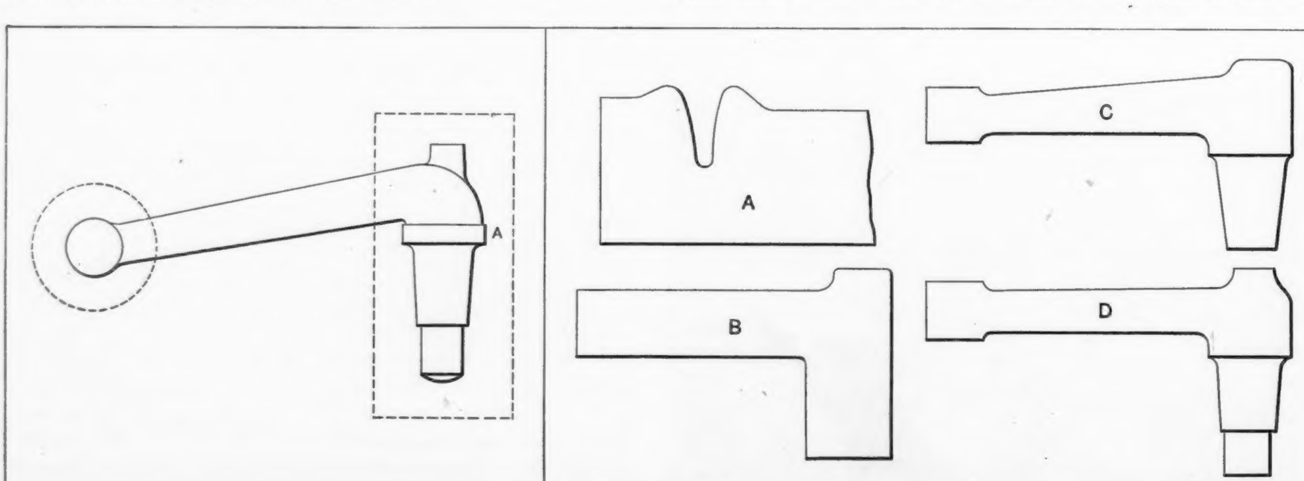


Fig. 39. Forging having a Sharp Bend

Fig. 40. Stages in forging Piece shown in Fig. 39

The hole in the boss may be punched in the same dies. By the other method, shown at *C* and *D*, the joint of the dies lies in the axis of the boss and the internal part of the fork is finished with projections made solidly in the dies. The hole can be punched subsequently as shown in Fig. 38. The objections to this method are that the web goes edgeways into the dies, which leave a mark around it, and the punching is done separately with less support for the boss.

Examples of Forgings with Sharp Bends

The forging shown in Fig. 39 may be made by bending either in iron or in steel. But in either material the curved portion

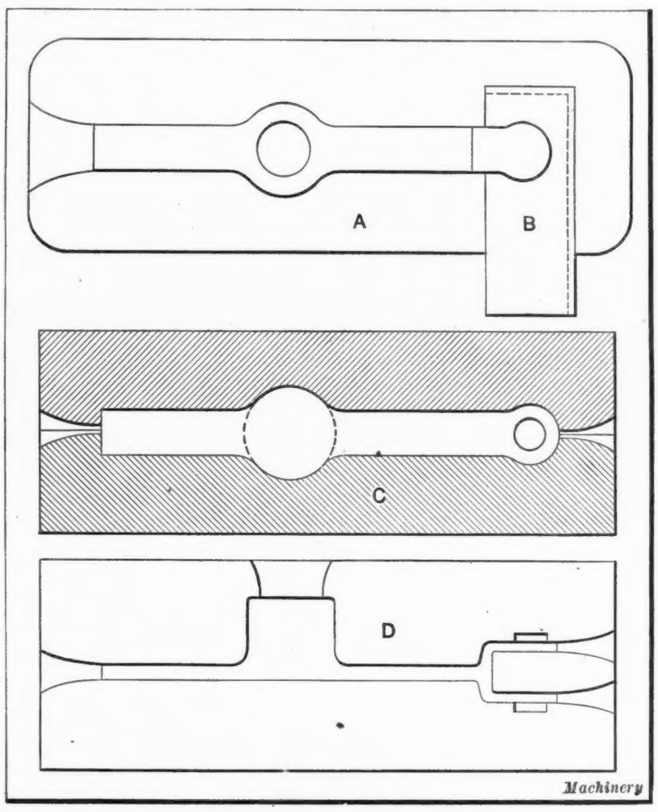


Fig. 41. Dies for forging Bar in Fig. 37

would be severely stressed, the outer fibers being strained excessively and the inner crumpled up. If made of iron, a weld is preferable; if made of steel, the bending must be performed at a high temperature and a good deal of work done in the elbow. The bar should be of the same diameter as collar *A*, or rather larger, so that there will be some reduction with the bending. A better way is to take a massive rectangular piece, as shown at *A*, Fig. 40, fuller it deeply as shown, and then draw down on each side under the power hammer to form the two arms. The second stage is shown at *B*, the third at *C*, and the fourth at *D*. The first rough reductions are made between the anvil and the tup, the second set between the bottom and top swages. Properly, the entire forging should be finished in dies because of the large number of

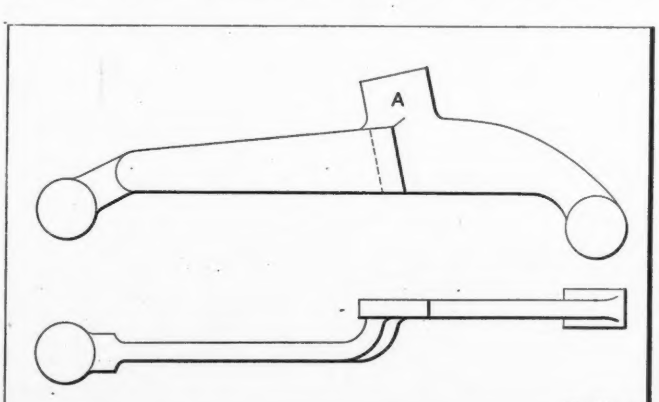


Fig. 42. Lever made from Straight Piece of Bar

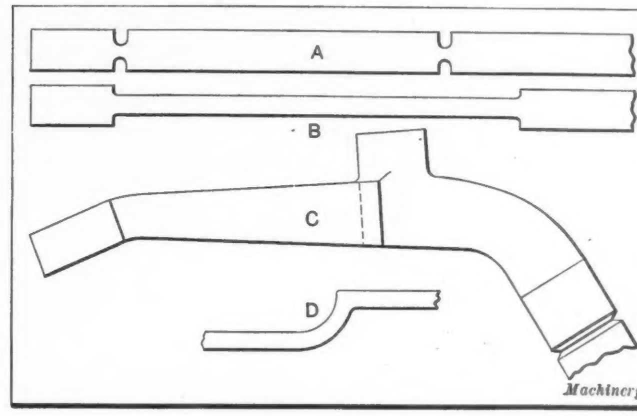


Fig. 43. Preliminary Stages in forging Lever

changes in dimensions; or the part adjacent to the bend may be made in one pair of dies and the bossed end in another pair, leaving the stem to be finished in swages. The outlines of these sectional dies are indicated by dotted lines in Fig. 39.

The curious lever shown in Fig. 42 is made from a straight piece of bar roughed down under the hammer and finished wholly in dies. To employ sectional dies only for the ball at one end and the boss at the other would still leave a good deal of awkward work to be done about the central portions. To make this lever, a bar having a cross-section rather greater than that of the boss and the ball is fullered in and drawn down, as at *A* and *B*, Fig. 43, to form the web thickness. Width is required to give material for the abutment piece *A*, near the center in Fig. 42. The forging is first dummied down as a straight piece. The blows should alternate between the flats of the web on each side, mostly on one edge in order to make the abutment portion *A* stand out from that edge. As shown at *D*, Fig. 43, the web is set down beside this portion *A* under the hammer, and the ends are bent over the edge of the anvil, or over a block having a curved face. At this stage the forging

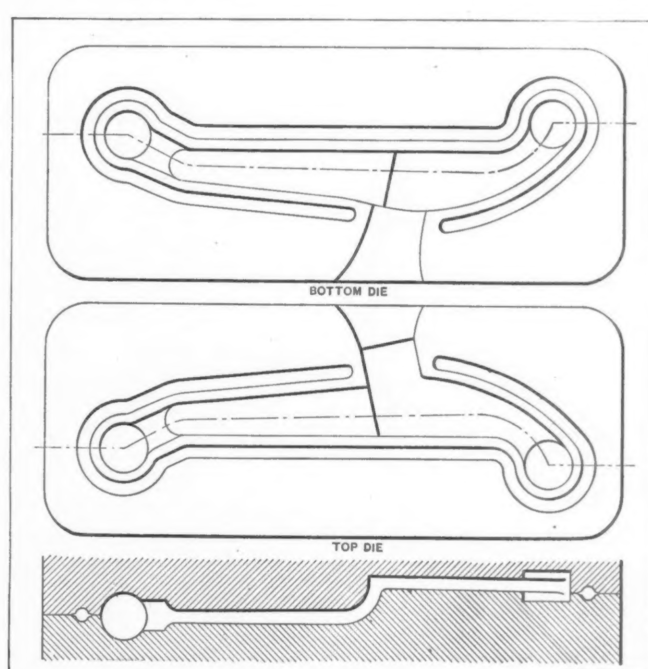


Fig. 44. Dies used in forging Lever shown in Fig. 42

is as shown at *C*, Fig. 43. A templet may be used to check the curvatures. The end of the bar that served as a porter is then cut off, and the rough forging put into the dies shown in Fig. 44. These are not quite alike at the abutment portion. They are shown thrown open in the joint face and have gutters to receive the fin.

Forging Crossheads

The crossheads in Fig. 45 are examples of a class of forgings in which two substantial parts stand at right angles with each other. The difference between the two is that the crosshead

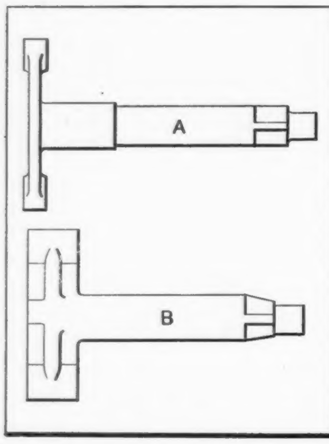


Fig. 45. Common Types of Crossheads

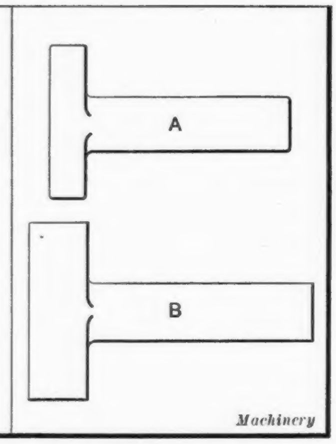


Fig. 46. Preliminary Stages in making Crossheads

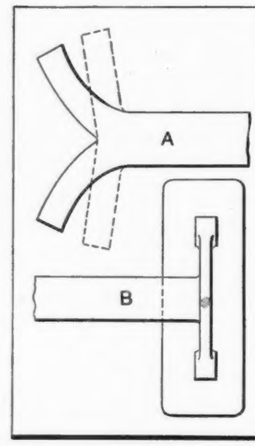


Fig. 47. Making Slender Crosshead in Iron

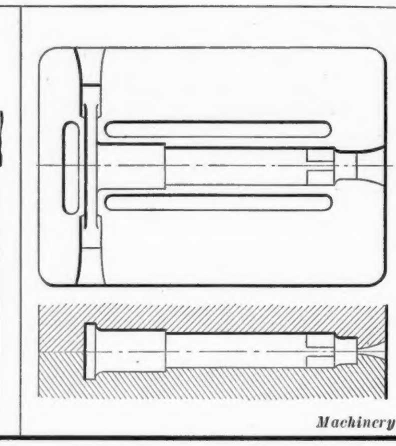


Fig. 48. Dies for making Slender Crosshead in Steel

portion is relatively slender at *A* and comparatively heavy at *B*, which suggests a variation in the method of treatment. When making the crosshead *A* of iron, the correct method is to divide one end of a round bar, open it out as at *A*, Fig. 47, and bend the forks to a right angle, or nearly so, following which the finishing may be done in dies. Only the crosshead and a small part of the stem need be finished in dies, which are shown at *B*; the stem may be made with swages under the steam hammer, unless large quantities have to be made.

When making the crosshead of steel, the better method is cubical lump of about the same section as the crosshead should be taken and the stem drawn down as at *B*, Fig. 46. This would be suitable for either iron or steel; the finishing may then be done in dies like those shown in Figs. 47 and 48. The ribbings must be stamped wholly in the dies, for little preliminary work can be done there. The fin can be taken care of, as shown in Fig. 48, at the ends of the bosses and in gutters, and the dies may include the entire forging or the crosshead only.

The crossheads shown in Figs. 49 and 50 are examples of

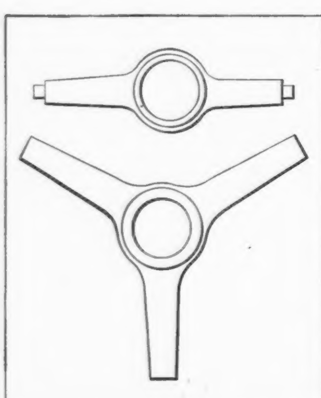


Fig. 49. Two-arm and Three-arm Crossheads

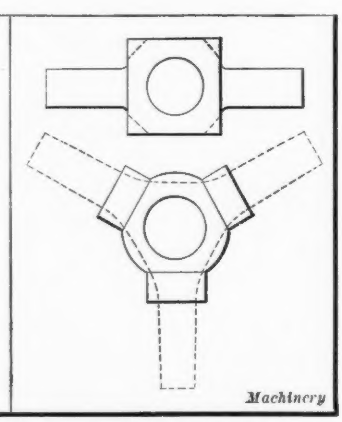


Fig. 50. Preliminary Work in forging Crossheads in Fig. 49

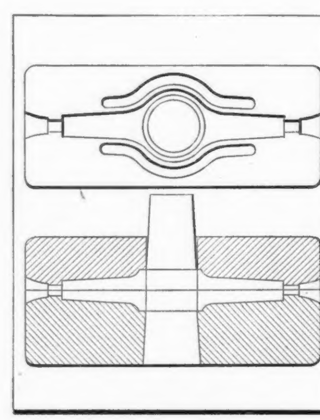


Fig. 51. Dies for forging Two-arm Crosshead

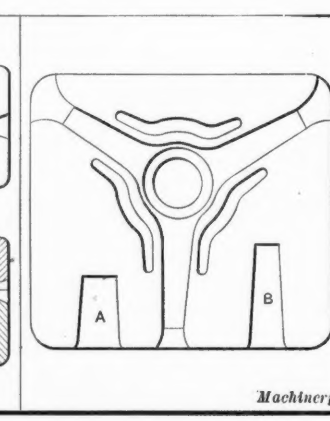


Fig. 52. Die for forging Three-arm Crosshead

to take a bar larger than the stem, to afford sufficient material for spreading, and draw down at one end, and on opposite sides to provide material for the crosshead bosses as at *A*, Fig. 46; the web portion is then reduced in dies and the stem is swaged down under the hammer, being finished in the same dies as the stem, Fig. 48. This is alternative to the method shown at *B*, Fig. 47. Gutters are provided for the fins to flow into.

The proportions of the second crosshead *B*, Fig. 45, are different, there being a more substantial head. To make this, a preliminary drawing down and punching and finishing in dies. They each comprise a relatively large central boss and hole, with tapered cylindrical arms of much smaller section. The method just mentioned is therefore the only feasible one.

The two-arm crosshead shown in the upper view, Fig. 49, is first roughed out from a solid square bar, as shown in the upper view, Fig. 50, from which two ends are swaged down to form the arms. The corners of the boss are cut off with a hot set. The hole may be punched at this stage and finished later in dies, or the punching can be done in dies. The ad-

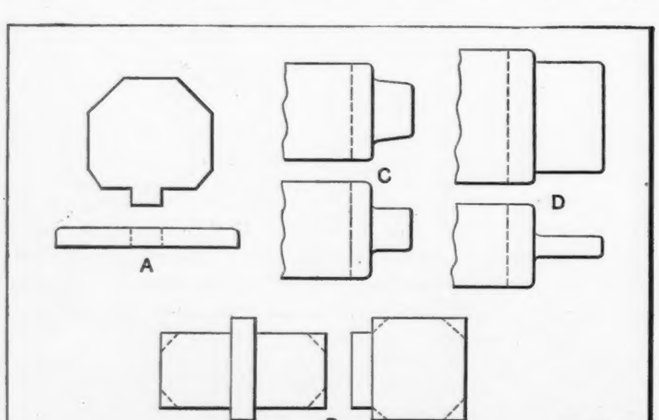


Fig. 53. Stages in making Some of the Eye-plates shown in Fig. 56

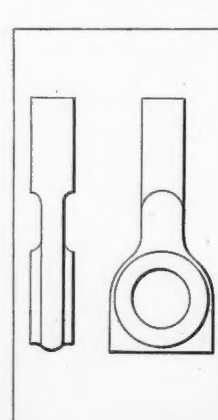


Fig. 54. Eye-plate made from Large Bar

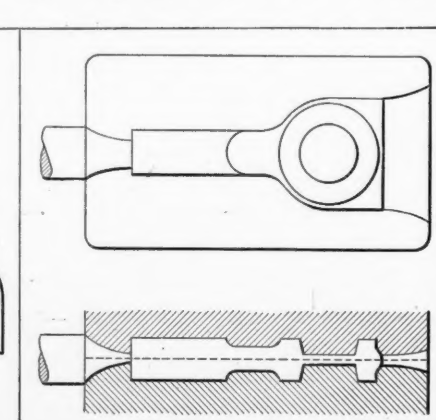


Fig. 55. Dies for making Eye-plate from Large Bar

vantage of the latter method is that the metal is well supported against the punch. But as the lump is quite heavy, the hole may be punched as a first operation before drawing down. The dies are shown in Fig. 51 with provision for making the hole. If the hole has been roughly punched, it can be finished in these dies either by driving a bellied drift through or by forming punches in each half die; the latter should not quite meet in the center. The provision for receiving the fin is shown.

The three-arm crosshead shown in the lower view, Fig. 49, is treated similarly. A circular lump is swaged down in three equidistant places and the interspaces worked back with the help of fullers. The lower view, Fig. 50, illustrates stages in the work—the full lines an early stage and the dotted lines a later one, following which it goes into the dies. One half die is shown in the joint face, Fig. 52. The two recesses *A* and *B* are used for swaging down the arms nearly to the finished dimensions before putting the forging into the dies to

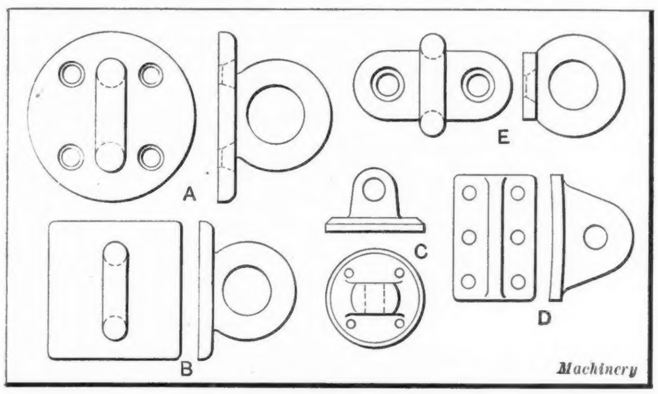


Fig. 56. Types of Eye-plates

be completed. The central hole may be made in the same manner as in the two-arm crosshead.

Forging Eye-plates

Eye-plates are made in various forms, as shown in Fig. 56. The pieces of metal from which they are formed bear little or no resemblance in outline to the articles produced. Dies are essential if labor is to be reduced. The plate, or foot, is the proper element to start from if the forging is to be made in the solid. The objection to this is the thickness of metal to be severed. This, however, is a matter of little mo-

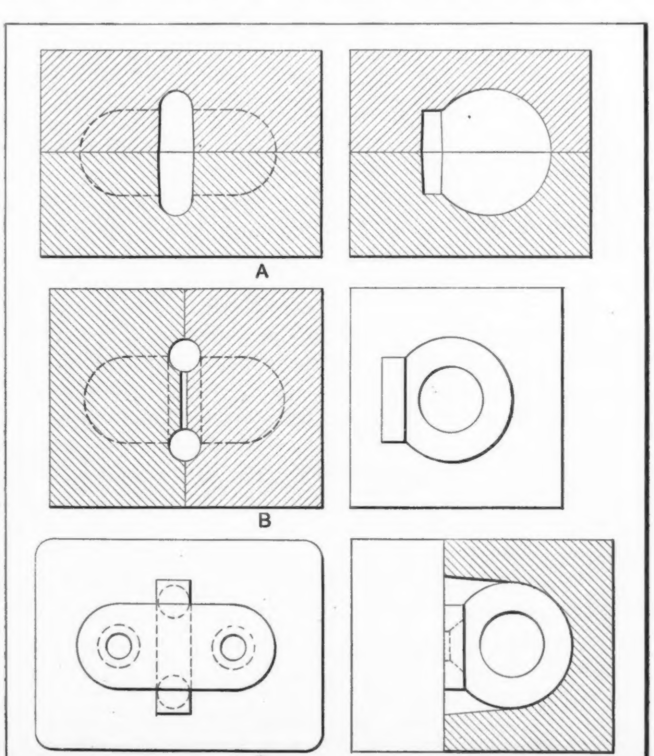


Fig. 57. Dies for making Eye-plate E, Fig. 56

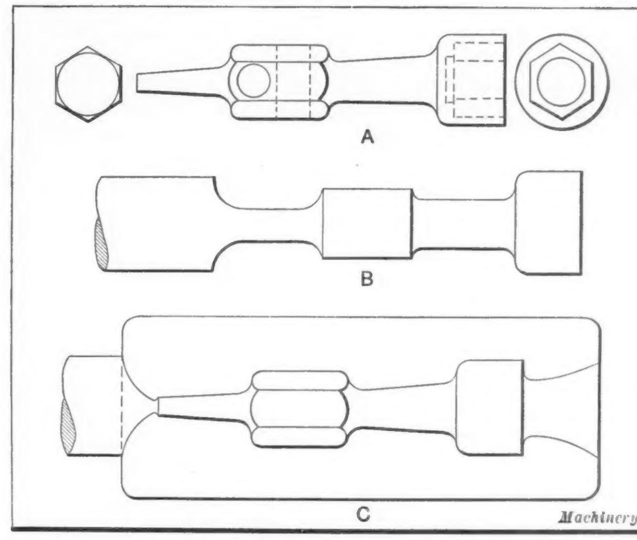


Fig. 58. Making a Box Spanner

ment if a hot saw is available; severance with a set would be tedious. The alternative is to weld the eye and the plate together, in which case each portion can be cut from pieces of plate having the approximate finished outlines. A tenon joint *A*, Fig. 53, will help the union.

Another method, suitable for producing the shape shown at *E*, Fig. 56, is to take a square piece rather larger than the diameter of the eye and thick enough to permit of fullering down material for the flanges, as at *B*, Fig. 53. The corners having been cut off with the hot set, the finishing can be done in successive pairs of dies. In consequence of the depth of the plate, it is best to divide the formation between two pairs of dies. The first pair *A*, Fig. 57, imparts the curves to the edges of the plate and the circular outline to the eye.

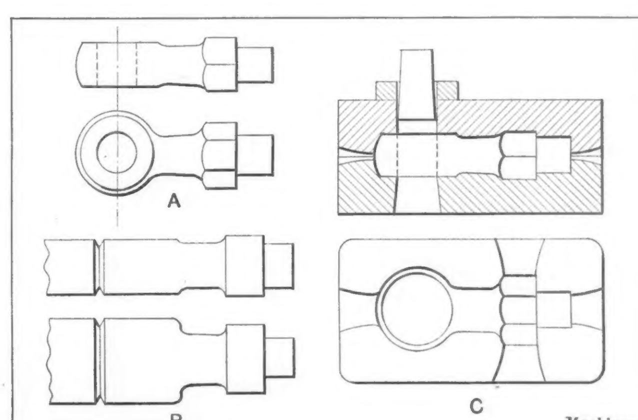


Fig. 59. Making Pillaret from Round or Rectangular Bar

A little draft is put on the vertical faces to favor the delivery of the forging. Afterward the forging is put into the next pair of dies *B*, which stamp the eye. The punching portions do not quite meet in the center, thus leaving room to receive the fin. If the screw holes are punched, this is done in a third pair of dies *C*. The method of dummying generally used is shown at *C* and *D*, Fig. 53. That illustrated at *C* is used for the eye shown at *C*, Fig. 56, and the method illustrated at *D* is used for the eye shown at *D*, Fig. 56. The bars are then cut off at the dotted lines with the hot saw, and the remainder of the work is done in dies similar to those illustrated in Fig. 57.

The eye shown in Fig. 54 is produced from a bar of about the size of the diameter of the eye, and the stem is drawn down roughly under the hammer. It may then go directly into the dies shown in Fig. 55. The hole is punched nearly half way in each die, leaving a space between to receive what fin forms there. Enough provision is made at the ends for squeezing out the fin from the boss and stem.

The box spanner, shown at *A*, Fig. 58, is easily forged if the hexagonal recess is omitted, this being a case for reduction only. A bar of the same diameter as the spanner end

is swaged down, as shown at *B*, and finished in the dies *C*, which also nick and practically sever the forging from the porter bar.

The pillaret shown at *A*, Fig. 59, is easily made from either round or rectangular bar, as shown at *B*. Using the latter, the fullering and swaging produce the rough outline indicated. After being cut off, it goes into the dies shown at *C*. The punching may be done as shown, or by having each half of the punch solid in each half die.

* * *

CUTTING A METRIC PITCH WORM

BY GUY H. GARDNER[1]

A delicate and costly piece of astronomical apparatus, imported from Europe, was badly injured in transportation, a hardened steel worm, on whose accuracy the usefulness of the instrument largely depended having its thread broken in several places. It was sent to a large city jobbing shop, which declined to undertake the repair, as it "had no facilities for cutting metric threads." Its owner then applied to a country job shop near his summer home, which made a new worm to his complete satisfaction. The rural mechanic confesses that he might not have undertaken the work if he had realized that the thread was metric, but having started the job he would not give it up, and proceeded to find means for carrying it to completion.

The worm had evidently been cut with a tool of 29 degrees angle, and by measuring the worm-wheel, counting its teeth, and then calculating the spiral angle of the worm, he had all the required data. Having no metric micrometer, and little if any knowledge of metric gearing, he made his calculations exactly as if the apparatus were of indigenous manufacture. This, if done arithmetically, would have involved him in a maze of fractions, but as he is expert in the use of logarithms he found by a single operation the logarithm of the axial lead of the worm, $\bar{2}.786822$, which corresponds to 0.0612 inch, about.

He had no gears to cut this lead, of course, but he knew how to make a lathe cut a slightly coarser lead than that to which it is geared by setting over the taper attachment and tailstock to the proper angle, a wrinkle which he had employed in threading taps with a slightly increased lead to compensate for shrinkage in hardening. The next finer lead at his command was 17¼ threads per inch, which he could get by compounding in the ratio of 2:3 with the gears for a 11½ pipe thread. This lead is about 0.0579 inch. Dividing the lead to which the lathe is geared by that desired gives the cosine of the angle of set-over:

[1]Address: New London, N. H.

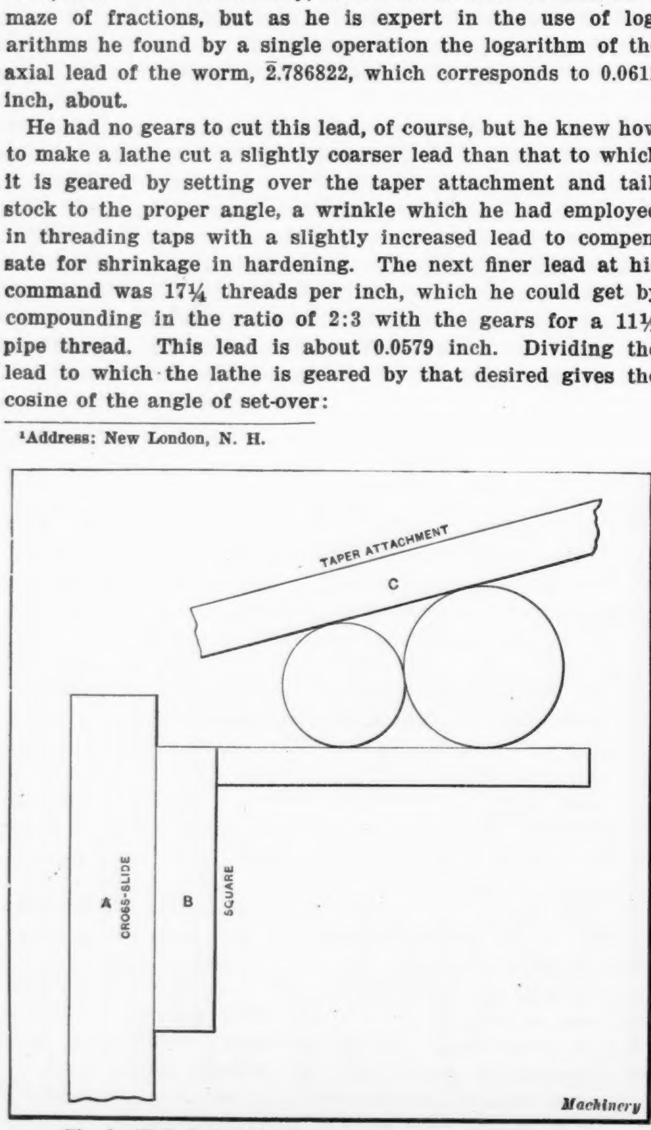


Fig. 1. Method of setting Taper Attachment with Two Disks

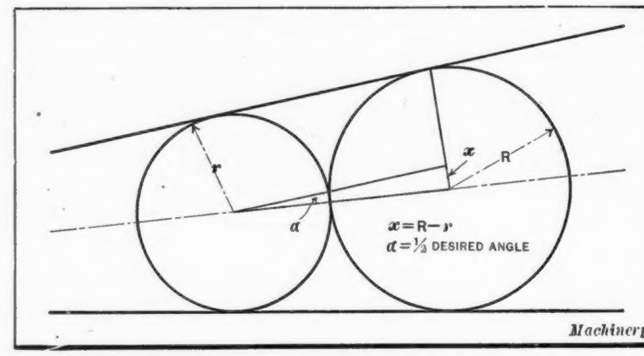


Fig. 2. Diagram to illustrate Formula for finding Disk Diameter used in setting to an Angle

Log of lead (17.25 threads per inch)	$\bar{2}.763211$
Colog[1] of lead desired	1.213178
Log cosine of angle of set-over	$\bar{1}.976389$

which shows the angle of set-over to be 18 degrees, 43 minutes, 20 seconds.

He did not feel certain how exact a setting was necessary, but determined to secure the highest degree of accuracy in his power. The method adopted is shown in Fig. 1. A steel square *B* was used, with its beam clamped against the cross-slide *A*, the taper attachment *C* being set by placing between it and the square blade two disks, in contact with each other; one was one inch in diameter and the other of such size (yet to be determined) that their common external tangents would be at the required angle, 18 degrees, 43 minutes, 20 seconds.

Referring to Fig. 2, the formula for finding the difference x between the radii of the two disks is $x = \dfrac{2r \sin \alpha}{1 - \sin \alpha}$, r being the radius of the smaller disk, and α one-half the desired angle. On substituting the known values the calculation gives 0.1943 inch as the value of x. All the preliminary figuring now being complete, he made the worm of "non-shrinking" steel, and after hardening polished it with a zinc lap and diamantine.

There may be better ways in which he might have done this job. Certainly an element of inaccuracy is introduced when a thread is cut on work set out of line with the lathe bed, as its angular velocity of rotation does not exactly correspond with that of the spindle, but nevertheless the worm made as described above has filled the very exacting requirements imposed by its position in a piece of astronomical apparatus to the entire satisfaction of its owner.

* * *

BRITISH GUN AND SHELL PRODUCTION

Great Britain has now reached its maximum gun and shell production, according to the Ministry of Munitions, so that there will be a gradual return of plants and labor to domestic and export production. In addition to the regular government factories, 4623 plants are now controlled by the government; in these, 2,225,000 persons, or about one-half the entire membership of the trade unions, are employed. The present capacity of these plants is shown by the statement that for every heavy howitzer produced in June, 1915, 323 are produced now; for every field howitzer produced then, 46 are produced now; and for every gun of medium size produced then there are 66 now. The output of 60-pounders and 6-inch guns went up eighteenfold and has now dropped back to twelvefold, as the supply is too great. In a single day, as many shells for heavy guns are made as were turned out during the whole first year of the war; and in a week the factories turn out as many shells for field howitzers and 3-inch field-guns as were turned out in the first year of the war.

[1]Tables of cologs are not common, and it is not out of place to state for the benefit of those who are unfamiliar with them that the colog of a number is the remainder after subtracting its log from zero, the mantissa being made positive. In the absence of a table, cologs may be easily derived from a table of logs. Cologs have no properties essentially different from those of logs, except that they enable division to be carried out by addition instead of subtraction, since the addition of a colog is the same as the subtraction of the corresponding log. In the case of division of fractions, as in the above, the use of the colog of the divisor simplifies the operation and avoids confusion due to the negative characteristics.—EDITOR.

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

LAYING OUT A HOPPER MITER JOINT

A machinist, enjoying a day off, strolled into a carpenter's shop and watched with interest the labors of a trade so unlike his own. Presently he noticed a man marking out pieces of board which he saw, from the drawing on the bench, were to

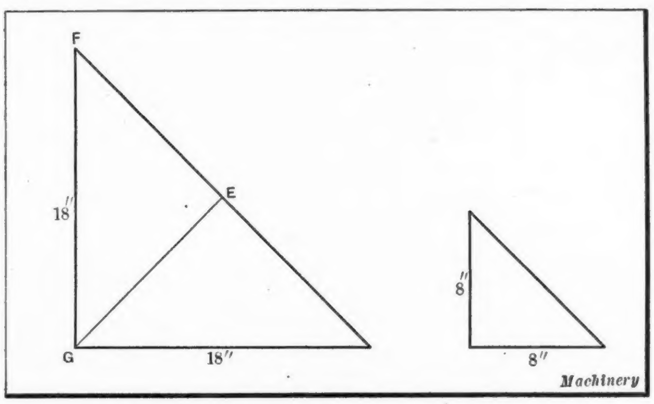
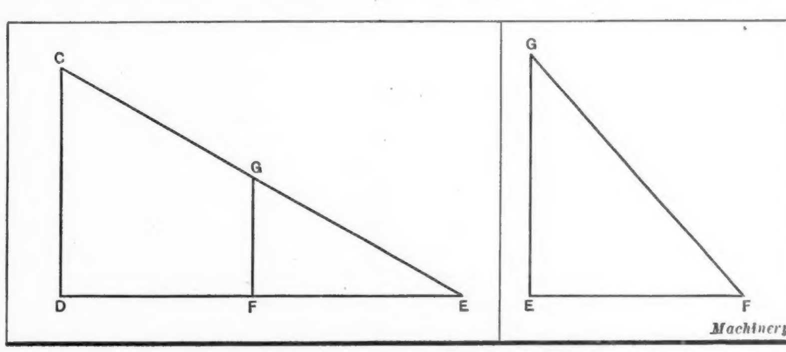


Fig. 1. Half-plans of Top and Bottom of Hopper

be the sides of a hopper, 18 inches square at the top, 8 inches at the bottom, and 12 inches high, with miter joints.

He was curious to see how the workman would obtain the angle for the beveled edges of the sides, as he recognized the problem as one which he had often dealt with himself, when he had had to find the angle to which to set the planer head in making "bits" for thread tools. In this case, as we all know, the angle of the tool differs from that of the thread it is to cut, because of the front rake. Though he waited, expecting to see the carpenter divide the tangent of 45 degrees by the cosine of the angle of rake, thus finding the tangent of the angle for his bevel, nothing of the kind occurred. Instead, the workman took a smooth piece of straight-edged board and drew upon it some diagrams whose meaning and purpose were at first incomprehensible to the watcher. Soon, however, he began to understand their aim, and this is what he discovered:



Figs. 2 and 3. Diagrams for laying out Miter Joints for Hopper Sides

The first triangle, 18 inches on a side, Fig. 1, represents a half-plan of the top of the hopper, the smaller, 8 by 8 inches, that of the hopper bottom. Measuring the two hypotenuses, the carpenter found their difference, which he transferred to the diagram Fig. 2, where he laid it off on the perpendicular, *CD*. (He could have found this difference more easily by making a triangle 10 inches on a side—(18 — 8)—and taking its hypotenuse, but he was probably unaware of this fact.) Now, making *DE*, Fig. 2, equal to twice the height of the hopper and drawing *CE*, he had the "angle of rake" graphically determined. As $EF \div EG$ (Fig. 1) = tan 45 degrees,

$$\frac{EF}{\cos CED} \div EG$$ will equal the tangent of the desired bevel.

Hence, laying off in Fig. 2 *EF* equal to *EF*, Fig. 1, and erecting a perpendicular at *F*, he found *EG*, which is $EF \div \cos$ *CED*. Making *EF* and *EG* in Fig. 3 equal to the same lines in Fig. 2, he drew *GF*, set his bevel square to the angle *GFE*, sawed and planed the boards to this angle, and the job was done.

The inquiring bystander learned that the carpenter knew nothing of trigonometry and had no idea of the reasons for making the diagrams as he had, but simply followed the method taught him during his apprenticeship. If one may judge by the excellence of the joints in the hopper, this scheme is abundantly accurate for the use to which it is put, and its simplicity and ingenuity so impressed the spectator that he made a memorandum of it in his notebook.

New London, N. H. GUY H. GARDNER

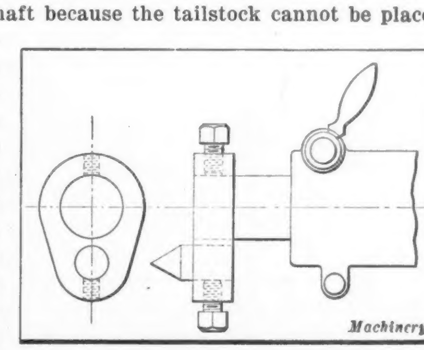
HOW A BROKEN SCREW WAS REMOVED

A few years ago I had a job quite out of my regular line, which was the result of an attempt to beat the plumber out of his prey. A brass flush box inlet valve leaked badly, and it was found necessary to put in a new cup leather in that part of the valve which balances the water pressure against the part closing the inlet. Both of the 3/16-inch screws holding the cap in place twisted off while being removed, but one yielded to the persuasion of a hammer and punch and was easily backed out. It was not so, however, with the other, which resisted all efforts to loosen it. Heating and cooling quickly did not work, neither did hammering or several of the other schemes used by machinists for backing out broken screws. Having no breast drill, it was truly a case of "being in a hole" until I thought of the expedient of sawing through the ear of the brass casting into the screw, and thus loosening it. The parts were then readily worked out. A 3/16-inch iron screw was then screwed into place. The ear was heated with a blowtorch, and a drop of acid and a bit of soft solder were applied which filled the saw cut as neatly as could be desired. The screw was quickly turned out, leaving a perfect thread, and the ear was practically as strong as before, as the saw cut had not weakened it. The remainder of the job was then plain sailing.

M. E. CANEK

TURNING TAPERS WITHOUT A TAPER ATTACHMENT

On lathes without a taper attachment, it is difficult to turn a taper on a long shaft because the tailstock cannot be placed far enough off center. The device shown in the accompanying illustration makes it possible to bring the center as far over as may be necessary. It can be made with little expense and used in many cases. It consists of a ma-



False Center for turning Tapers

chine steel body, which is fastened on the tailstock barrel by means of a set-screw, and a tool-steel center, which is also fastened by means of a set-screw, as shown in the illustration.

Plainfield, N. J. HENRY DAUT

LOYALTY OF EMPLOYERS AND EMPLOYES

Referring to J. P. Brophy's article on loyalty in the April number, I think that Mr. Brophy has more loyal employes than he thinks he has. A man is most willing to believe that which he most desires. If he is looking for loyalty he will get it, and if he is not expecting loyalty he will not be disappointed. It has been my experience that where loyalty exists it does not begin at the bottom and work up. On the other hand, it begins at the top and works down. You can generally judge an organization by the character of the man at the top. If he is constantly distrustful of his fellow-men, his fellow-men will distrust him. A successful manager should be a careful student of human nature. It is not necessary that he know all about his product from the foundation up; he can employ men who have the experience, skill and ability required for all that. His mission is to fit the square plugs into square holes—to act as a peacemaker and counsellor. The time has gone by when loyalty can be obtained by slave driving. Current events go to prove that better than any words of mine.

One of the greatest drawbacks in the average manufacturing plant is the distinction that is made between the men in the office and the men in overalls. To regard these men as being of different clay is a great mistake, and I am glad to say that some concerns have seen light, and shape their policies on the basis that the men in the shop are just as essential to the welfare of the organization as anyone else connected with it. Say that a manufacturer is building a machine that requires careful and accurate work and extremely careful inspection to fulfill the requirements demanded of it; has the man in the office, or, in fact, the head of the concern, any control over the product? No; he must trust the inspector or the workman. No matter how well the instructions may be drawn up, a manufacturer always has to depend on his workmen to maintain the excellence of his product. The necessity, therefore, for close and friendly cooperation between the management and the workmen should be obvious.

A fact that is many times lost sight of is that a man who, through economic conditions, is required to don overalls does not at the same time lose his intellectual capacity. Clothes do not make the man. The management that does not take into consideration the fact that the workmen are intelligent human beings makes one of the greatest blunders. In many cases a machine has been designed, the drawings made and everything looked over carefully to discover weakness and errors. But after all has been done to make the product perfect, errors have been found by workmen in the shop, who, by reporting them, have saved the concern a great amount of expense and trouble. If this is not an expression of loyalty, I do not know what is. Yet it happens every day in manufacturing plants. Another fact that might be mentioned in this connection is that the average employer does not think it essential to take the workmen into his confidence, but expects them to be loyal without any evidence of trust on his part. How can a manufacturer expect his workmen to be loyal when they are kept in the dark? Distrust on the part of the management breeds distrust in the workmen.

One point in the editorial "Building up an Organization" that is probably the keynote to the situation is as follows: "Concerns that make a practice of attracting men from other organizations by offers of high salaries are not organically sound, nor are they likely to become sound and efficient by pursuing this method of recruiting." The average manufacturer takes exactly the opposite view. He believes that money is everything to the workman, and in that conclusion he makes a big mistake. What could be more unsatisfactory than to have workmen employed from different plants put on the same work and given different rates, because one has the ability to sell his service for a higher rate than another? If there is no unity between management and workmen, there is in many cases a unity among the workmen. If one man gets fair treatment and the other does not, it is not long before the information travels and distrust spreads. A uniform scale of wages for a certain class of work with a bonus is the most satisfactory method of rewarding labor. The bonus should be fixed according to the rate paid as well as by the efficiency of the workman. Had it not been for the distrust of manufacturers and a lack of loyalty toward their men, workmen would never have cooperated to form unions to fight them. Protection is an instinctive element of human nature. If the manufacturer does not protect his workmen, the workmen must protect themselves.

In reference to one part of Mr. Brophy's article I wish to make further comment. Does Mr. Brophy appreciate the psychological effect of these remarks on the men in his employ? He says, "No matter what you do nor how you do it, can you for one minute feel safe when you have labor troubles?" In answer to this I would say that the only way to avoid it is not to have labor troubles, and the only way not to have labor troubles is to deal honestly and fairly with your men. Fair treatment always brings fair treatment in return. You can't buy loyalty with a gold brick.

Springfield, Vt. DOUGLAS T. HAMILTON

Having read the article in the February number of MACHINERY entitled "Building up an Organization," and also the article entitled "Loyalty" in the April number, the writer wishes to give a workingman's idea of the word "loyalty."

When a young man, or rather a boy, starting out as a machinist after having been kicked and cuffed through three years of apprenticeship as a "bound-out boy," the writer had the idea that all owners of shops had their heads together "to get him," for it seemed as if he could not stay in a shop over three months, no matter how hard he worked. At last he got a job that lasted three years. He attended night school and heard many lectures, most of them on the subject of loyalty, or else containing illustrations showing that a person should always be loyal to his employer. The writer was advanced several times and at last placed in the tool-room, where, apparently, there were all kinds of chances to get ahead.

At this time an organizer entered the shop and formed a union. The men were not paid as well as in some shops in the city, and some of the gang bosses were unusually severe; so, as the company would not remedy this, a strike was called. The president of the firm spoke to the men and his talk was mainly on loyalty. He said that he had always done the right thing by his men, so they ought to wait until he could afford to pay more, etc. As for the foremen, he claimed that they were efficient men and could not be removed. As several of the men had been discharged by these bosses for some slight mistake, which they could have remedied and which others did remedy, all the men looked forward to their removal.

A strike was called. Two men in the shop and two in the tool-room (the writer was one) would not strike, but kept on working because the president, in a personal talk to each man, promised to protect and care for every man who would stick by him. That strike lasted three weeks, after which the president gave in. When the strikers returned, the four men were told that they would be given twenty minutes to get out of the works. They went at once to the president's office, where they had trouble gaining admission; and when they entered, the president said to them, "Well, what do you men want now?" When the matter was laid before him, he said, "Well, the only thing you fellows can do is to square yourselves with the union," and when told that the union would give each man a card only on payment of $50 and a promise to get out of town, he laughed and said, "Well, you made $50 in three weeks, didn't you? Get out." That was all.

Practically the same thing happened a few years later in a plant capitalized for half a hundred million dollars, when the writer again stayed in, only to be kicked out later on. The third time this happened he was buying a house while working in a railroad shop. The strike lasted two years; but before that time, when he had worked twenty hours a day for four days and also had had sickness at home so that he had

been unable to sleep, he laid off one day without asking permission. When he returned to work the master mechanic reprimanded him severely. Later, when a bolt which he had tightened up had stripped the threads and fallen out, so that one end of the crosshead guide of the locomotive fell down, he was told that he could go to work pending an investigation; afterward he was discharged.

Now, Mr. Editor, will you kindly tell the writer what pay he has received for being loyal? The owners, through their foremen, do not stand on ceremony in giving any employe the little end of any deal, so why should a man endanger his standing with his fellow-men by doing or saying anything in favor of an employer, who will not live up to his word a minute if his pocketbook is touched for a dollar thereby?

The writer tries to be honest. He tries to give an honest day's work and to make his word as good as any bond issued by a national bank, but he cannot and will not give loyalty to a corporation whose head will only say "square yourself" and then "get out." There are thousands who have had this experience, and more are learning the lesson every day.

Miles City, Mont. C. G. Williams

In the April number of Machinery there is an article entitled "Loyalty," in which an effort is made to show that loyalty is not a common trait of employes, and the attitude of the employes in cases of labor troubles is considered to show this. But if there had been a general spirit of loyalty, there would have been no labor troubles. Why not consider those shops that have not had labor troubles?

Loyalty is a natural trait of humanity—loyalty to any organization with which a person is connected, whether it is a school, shop or country—and it takes considerable to change this spirit to hostility; however, it can be changed. It is not long ago that I was acquainted with a management that appeared to be trying to change the spirit of the employes to hostility, not by anything that would be considered objectionable by a social reformer, but by simple ignorance of human nature.

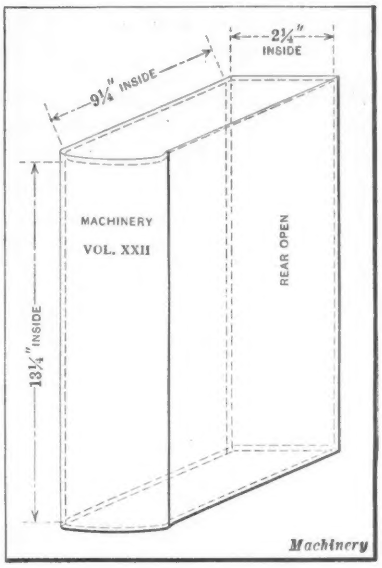
The fact that an employe has been working for one shop for a long time is no indication of loyalty. In many shops, it shows that he has not enough energy to look for a better position, and no more energy should be expected in showing his loyalty. There is probably as much loyalty to the American small college as to any organization aside from the nation, but this seldom results in an additional year at the college. A loyal employe is one that will stand by the employer when he is needed, not one that will decline an opportunity to advance when no injury will be done thereby. The writer's experience with labor troubles is quite limited, as he has never seen any, either as employe or employer, but he has seen enough of both large and small shops to be convinced that loyalty is the rule wherever it is given an opportunity by the management.

Worcester, Mass. A. W. Forbes

CONVENIENT FILING SYSTEM

Doubtless many Machinery readers make some attempt to preserve and file for future reference the matter published from year to year. But among the methods suggested from time to time, none has really satisfied the three chief requirements: convenience, minimum labor, and cheapness. I decided that all the published matter should be kept; and the value of doing this was shown a few months ago. Having accepted a new position, I began to search the files of Machinery for articles on the special line into which I was going and found a comprehensive article upon the shop methods of the very firm with which I was to be connected. If only the matter of interest at the time this article was published had been preserved, this article would undoubtedly have been discarded with the others.

I wanted a system that would allow any particular article or diagram to be withdrawn for use on a drawing-board if necessary, and that would protect the papers from dirt and wear. It is now about two years since the system was devised, and it has given complete satisfaction. About a dozen cloth-covered cardboard cases like that shown in the illustration were procured from a bookbinder. The papers were then prepared for filing, which actually required about fifteen minutes per volume, by grasping the open edge of the copy with the left hand, leaving about fifty pages at the back free, and with the back of the copy facing upward, tearing the free pages at the back off the binding wires with a quick motion of the right hand. The binding wires now project so they may be cut off with wire nippers and the rest of the advertising at the back may then be readily removed. It will generally be found that the article and the advertising sections come between two of the many units that make up the magazine, so that there will be no need of tearing the pages where they fold at the back. The article section may be removed by simply lifting it from the wires. This plan gives a loose-leaf collection of all the articles in the magazine. These pages are placed in the cases, twelve issues to a case, and are ready for use after the title and volume number have been placed on the front. If it is desired to keep any of the advertising pages, they should be filed in a separate case.



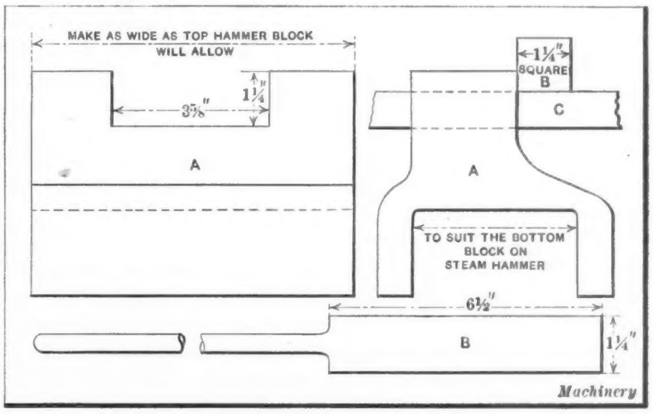
Convenient Magazine File

The indexing is simple also; all the annual indexes issued by the publishers are kept in a separate case, so that the more recent matter may be consulted first. On one side of the case is pasted a blank sheet of paper for noting the withdrawal and return of matter used. For carrying papers to the shop, a cardboard folder with protecting flaps is used.

Springfield, Mass. Wilfrid Griffin

CUTTING BLOCK

The cutting block shown in the accompanying illustration may be used in a blacksmith's shop that does not have shears for cutting steel. The writer has used it for years and has thereby saved much time. The block *A* is fitted on top of the



Block for cutting Steel under Steam Hammer

bottom block of the hammer, so that the cutting edge is over the center. In the side view a piece of steel *C* is shown ready to be cut off. As the hammer strikes the block *B* it shears the steel. Both blocks are tempered. Block *B* has a handle about three feet long, so that it can be held with both hands. The piece being cut should be held firmly, or it will jar when the hammer strikes the top block. With this device, it is possible to cut steel up to 1 by 3½ inches with one or two blows of the hammer.

Plainfield, N. J. George C. Dawson

MACHINING RIFLE PARTS IN THE AUTOMATIC SCREW MACHINE

The automatic machining of parts for military rifles frequently necessitates the design of unusual tools and attachments for use in the automatic screw machine. Fig. 1 shows

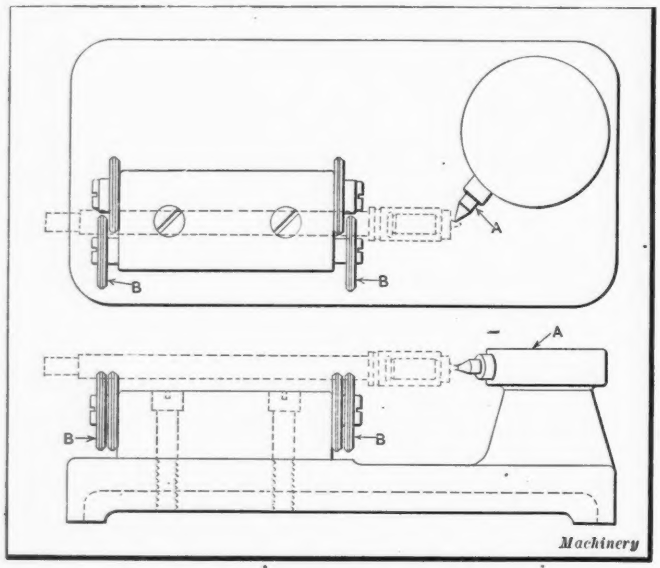


Fig. 1. Testing Concentricity of Nose with Body

an assembled firing pin for a military rifle being tested by an indicator gage A. The firing pin consists of two parts, the body and the nose; the body is made from medium carbon steel and the nose from tool steel. In the illustration, the pin is shown resting on the rollers B on which it is turned while the gage tests the concentricity of the nose with the body.

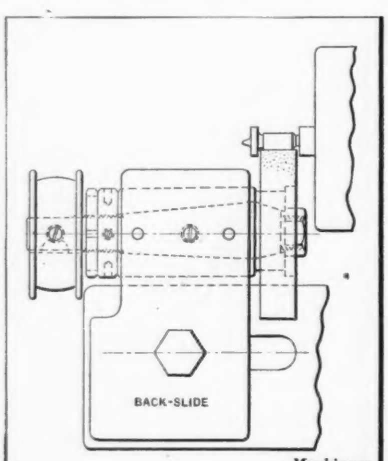


Fig. 2. Grinding Attachment mounted on Rear Slide

The nose section, as machined in a No. 0 B. & S. automatic screw machine, is shown in Fig. 6, and the circular forming tool is shown on the front slide. When finished, the nose section is hardened only on the point. The body of this section is ground to be a light drive fit in the internally ground section of the firing-pin body. The attachment for grinding, shown in Fig. 2, is mounted on the rear slide and the grinding wheel is driven by a flat belt ½ inch wide from the overhead works; an end view is shown in Fig. 3.

The cut is so light that it is seldom necessary to true the face of the grinding wheel. When this is done, however, the diamond and special holder shown in Fig. 4 are used. The holder is mounted in the turret and fed to the wheel by the turret operating handle furnished with the machine. When the truing device is used the spindle and the turret of the machine are covered with a cloth; the oil pan is also covered to prevent the emery dust from settling in it. When in use, the abrasion of the grinding wheel for this light cut is so slight that no trouble is experienced by the emery getting into the bearings. To make sure that it does not, however, the lubricating oil is replenished more frequently than is customary.

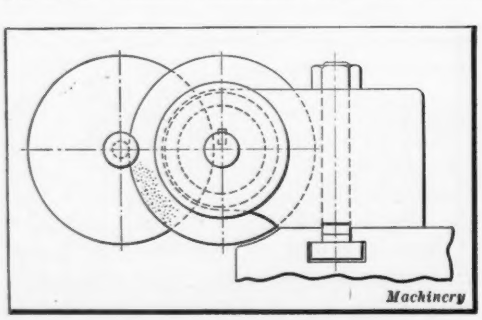


Fig. 3. End View of Grinding Attachment shown in Fig. 2

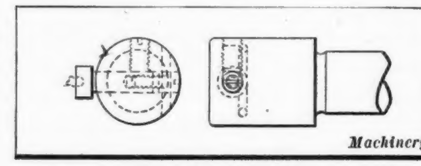


Fig. 4. Diamond and Holder for truing Emery Wheel

An attachment for diverting the flow of oil is shown in Fig. 5, where A is a link that connects the end of the oil-pipe to the rear cross-slide so that when the grinding wheel comes forward to the cutting position the oil-pipe is rotated by this link, swiveling on bracket B. The coil spring is not used to return the oil-pipe to position, but keeps the socket in contact with the tapered base, thus preventing a leak. As the oil-pipe and socket are revolved around the tapered base, the flow is automatically shut off by the socket closing the hole in the base. When the oil-pipe is in position, the link is attached to the rear cross-slide when the roll is on the bottom of the rear cross-slide cam. The order of operations is as follows:

Operation	Number of Revolutions	Hundredths
Feed stock to stop	12	2.5
Cut off, 0.04 inch travel at 0.0009 inch feed	47	9.8
Form, 0.18 inch travel at 0.0005 inch feed	361	74.9
Index turret while forming	(12)	(2.5)
Clearance	16	3.3
Grind, 0.003 inch travel at 0.0001 inch feed	30	6.2
Index turret while forming	(12)	(2.5
Clearance	16	3.3
Total	482	100.0

The spindle speed is 445 revolutions per minute, the maximum surface speed of the stock is 42 feet per minute, and for forming and grinding, 29 feet per minute. Hence, the time required for machining one part is 65 seconds and the net production is 490 in ten hours. The gears used are, driving shaft 30 and worm shaft 65. From 2.5 hundredths to 12.3 hundredths on the cam circle, the cutting-off part of the cutter enters the stock; and from

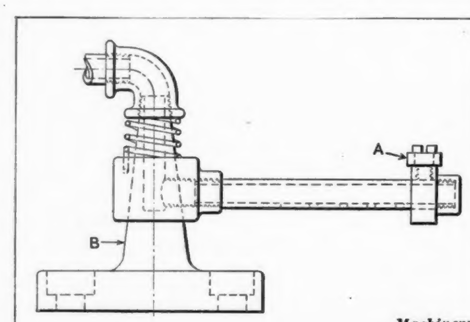


Fig. 5. Special Attachment for diverting Flow of Oil

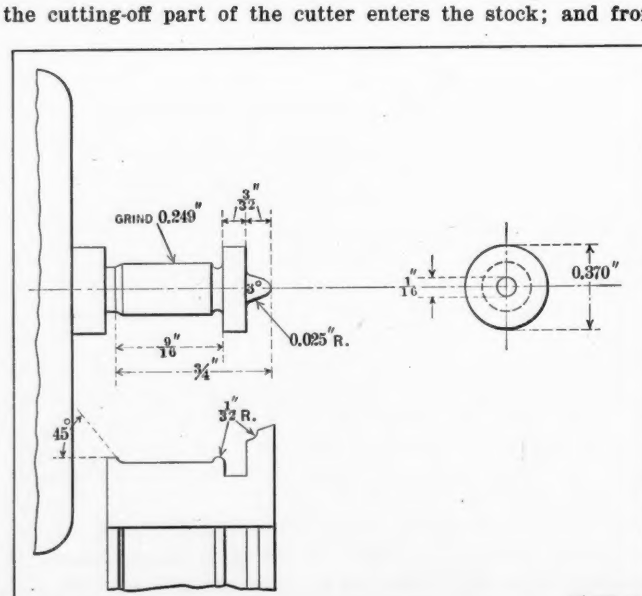


Fig. 6. Nose of Firing Pin and Circular Forming Tool

12.3 hundredths to 87.2 hundredths, the full width of the tool is cutting. The clearance from 87.2 hundredths to 90.5 hundredths is for shutting off the flow of oil, and the clearance from 96.7 to 100 on the cam circle is to allow the combination form and cutting-off tool to clear the stock before feeding to the stop.

EDWARD NEWMAN

SUCCESSIVE PRESS OPERATIONS

Very often an article is to be manufactured in several sizes which vary only in one dimension. For instance, the varying dimension in the case of the trial frame used by occulists when testing the eyes is the "pupillary" distance, or the center-to-center distance of the lens openings. These frames are made in four sizes, the difference in the pupillary distance of the smallest and largest frames being six millimeters. In Fig. 1 are shown the operations necessary to obtain the finished blank. The notching in the second operation serves as a locating point for the blanking operations. Without running into the curved outline of the blank, it is possible to vary the position of these notches three millimeters, which is the actual distance the dimension A must vary between the largest and smallest sizes.

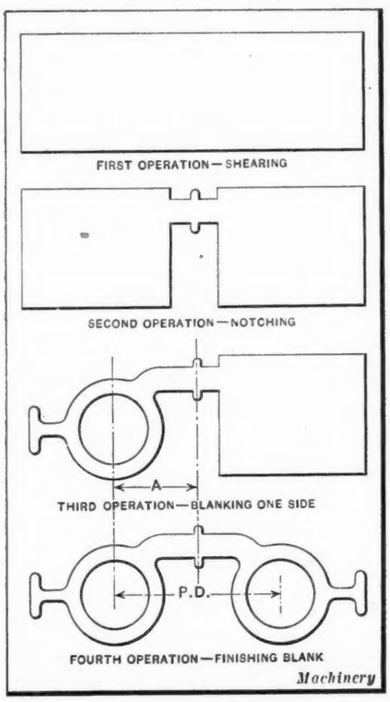


Fig. 1. Successive Press Operations in making Trial Frame

The distance A is regulated by the position of the guide B, Fig. 2; the method of holding is obvious. It will be seen that there are graduations for locating the different distances. Guide C is used only for the last operation of blanking, to keep perfect alignment of the lens openings; it is also adjustable as shown. Guide pin D keeps the blank in alignment for the second operation, the width of guide B not being sufficient, as it would allow the blank to cramp a little one way or the other. The pieces are ejected by a pad E, actuated by a rubber pad F. The method of supporting the notching punch is shown in Fig. 3. This punch is about 5/16 inch longer than the width of the blank. One-half of this amount on each side is allowed to enter the die before the punch actually begins to cut. This is a decided improvement when a punch does not cut on all sides, as it acts as a guide for itself and prevents the tendency to shear off to one side. The making of the tools in this way has saved several hundred dollars, and a satisfactory job is produced.

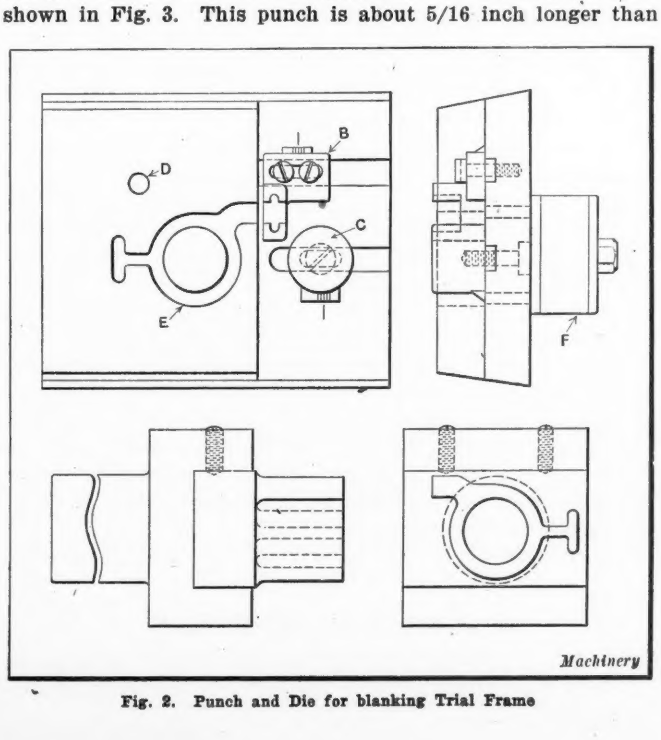


Fig. 2. Punch and Die for blanking Trial Frame

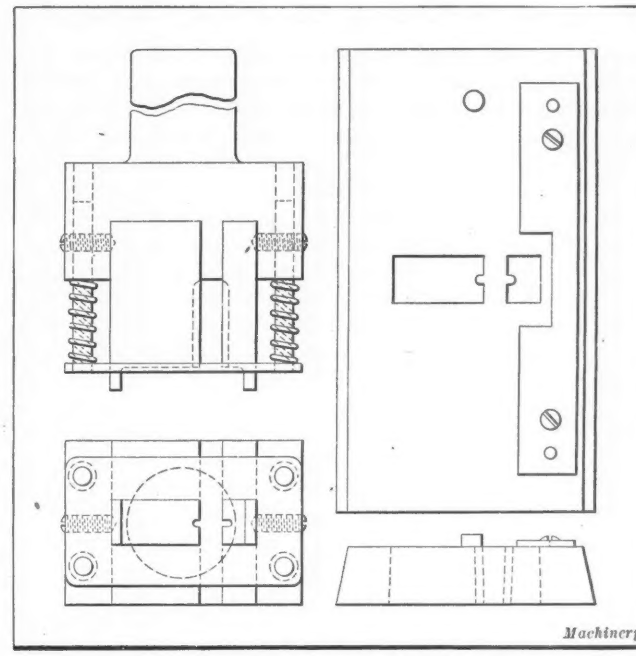
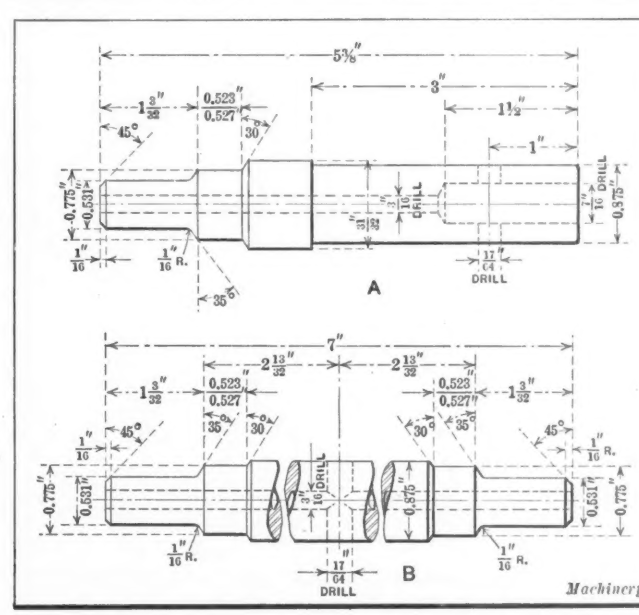


Fig. 3. Punch and Die for notching Trial Frame

Philadelphia, Pa. A. DANE

ECONOMIZING IN HIGH-SPEED STEEL

The high cost of high-speed steel in the last two years has been a strong stimulus to the generation of ideas for its economical use. A collection of these ideas will unquestionably form an interesting and useful chapter in any book on machine-shop practice. That a considerable saving can often be effected in a simple way is demonstrated by the cost of the reamers shown at A and B in the accompanying illustration. These reamers are used on standard automatics. The one shown at A cost \$9 when ordered in dozen lots. At B is shown a similar reamer, double-ended; this cost \$12, and twice as much service is obtained from it as from the old style. The saving thus amounts to one-third, or \$6 on every double-ended reamer. It will be interesting to note that the actual saving of material runs in the same ratio, namely, 7 inches, as against 10¾ inches, as do also the labor costs.



(A) Old Form of Reamer; (B) New Form that reduced Cost

M. V. T.

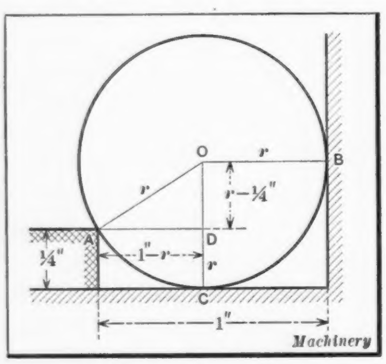
PLACING NUMBERS ON TWIST DRILLS

One great fault with the average twist drill is that the figures indicating its size are not stamped on plain or deep enough. The writer has found many brand-new drills on which the marks were so blurred that it was impossible to distinguish the size of the drill without the aid of a reading glass. If the drill should happen to slip a little in the chuck, the markings will usually be found to have been ground out beyond all signs of recognition. This trouble is particularly noticeable in the smaller sizes, from No. 30 to ⅜ inch in diameter. On work where the drills are constantly being changed, it means considerable extra labor to try out each drill in a drill gage to learn the size; and with unskilled labor this method will usually prove unsatisfactory. One way of overcoming this trouble is to stamp the size on the butt end of the larger drills and grind off a little on the side of the smaller drills and stamp the size upon this flat surface. When this method is used the marks cannot be ground off by the drill slipping in the chuck.

Plainville, Conn. HARRY B. STILLMAN

PROBLEM IN MENSURATION

A much simpler solution to the "Problem in Mensuration" in the February number of MACHINERY, is to draw radii OA, OB, and OC. Then draw AD perpendicular to OC. AD equals 1 inch — r and $OD = r - 1/4$ inch. In a right-angle triangle, the sum of the squares of the two sides equals the square of the hypotenuse; therefore $r^2 = (r - 1/4)^2 + (1 - r)^2$. Solving for r, $r^2 = r^2 - 1/2r + 1/16 + 1 - 2r + r^2$; $0 = r^2 - 5/2r + 17/16$. Adding $1/2 = 8/16$ to each side of the equation, $1/2 = r^2 - 5/2r + 25/16$, and $\sqrt{1/2} = r - 5/4$. $\pm 0.707 = r - 1.25$, $r = 1.25 \pm 0.707 = 0.543$, or 1.957. The diameter is $2r$, or $2 \times 0.543 = 1.086$ inch. The formula for this may be written, diameter $= 2\sqrt{(r - 1/4)^2 + (1 - r)^2}$, where r equals the radius.



Problem in Mensuration

J. L. L.

A simple solution of the problem in mensuration in the February number of MACHINERY is as follows: If B is the center of the circle, draw AC parallel to the base line and BC perpendicular to AC. Then in the triangle ABC, $AB = x$. It is evident that AC will then equal $1 - x$ and that $BC = x - ¼$; therefore, $(1 - x)^2 + (x - ¼)^2 = x^2$, which simplifies into $16x^2 - 40x + 17 = 0$. This simple quadratic equation, when solved, gives

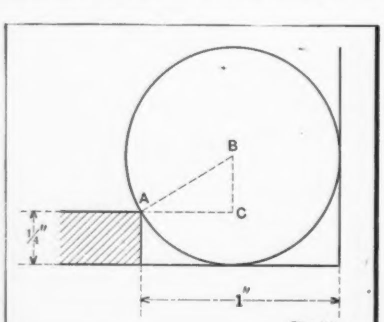


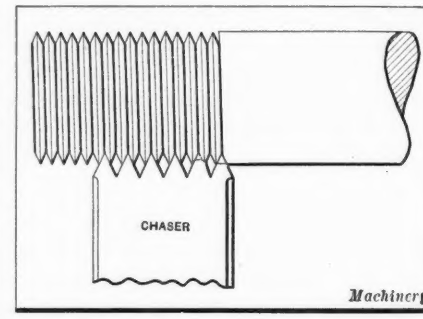
Diagram illustrating Problem in Mensuration

$$x = \frac{5 \pm 2\sqrt{2}}{4} = 0.5428$$ for the smaller value. The diameter is, therefore, twice this, or 1.0856.

Springfield, Mass. F. B. FULLER

CHASING A 100-PITCH THREAD WITH A 50-PITCH CHASER

A factory recently had forty parts of a certain product to manufacture which necessitated putting a 100-pitch vee thread on a steel bar about four inches long. At first, the thread was made with a 100-pitch chaser, but the finished thread was unsatisfactory; it looked like a drunken thread and chatter marks were plainly visible. As every effort to prevent this undesirable effect failed, a hob for cutting a fifty-pitch chaser was made and a six-tooth chaser was formed and hardened. As shown, the first tooth was backed off to cut into the piece only about one-quarter the depth of the thread. The next tooth was not backed off so much and went into the work a little deeper. These two teeth took what might be termed the roughing cut, and the remaining teeth took the finishing cut. The fifty-pitch chaser was put in a lathe geared up for one hundred threads to the inch. Its travel, as shown, appears to be in each alternate thread, but the travel really is in every thread, as the lathe is geared for one hundred threads to the inch. This chaser allows plenty of clearance, the teeth in it are stronger, and it is not so hard to make. Besides, it gives a satisfactory thread.

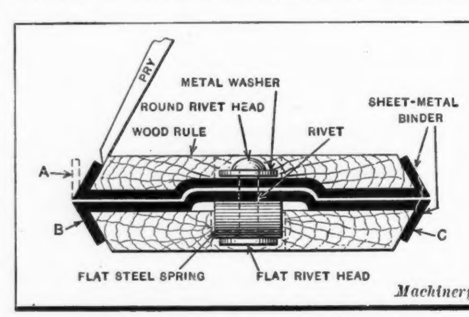


Six-tooth 50-pitch Chaser used for chasing 100-pitch Thread

New Haven, Conn. ERIC LEE

REPAIRING A BROKEN FOLDING RULE

A great many mechanics and other users throw away their folding rules when they break at the joint or elsewhere. Very often a broken section is mended with glue, and as the repair lasts only a short time, the mending is repeated several times; repairs made in this way are worthless. A break at the joint, wood section, or fold, however, can be easily and quickly repaired in such a way that the rule will be as good as new, although this is not done with a view to economy. Without a folding rule, the workman is at a great inconvenience and it may be several days before he can purchase a new rule. One large plant that keeps on hand a supply of these rules for the convenience of the workmen, passes out about three hundred and fifty rules each year. One-third of these are furnished free to the heads of departments and others, and the rest are purchased by the workmen. All broken rules are sent to one man, who repairs them. Rules that are not worth repairing are placed in a box, so that the parts may be used to repair other rules. The tools required in this repair work are a file, small hammer, guard, and pry. The pry is made from an old file about one-half inch wide, one end being slightly beveled as shown. The guard is made of thin steel, square or round, and has a hole in the center that fits over the head of the rivet. A repair is made as follows: With the pry, the sides of the metal clip are opened, as shown at A; if only the flat spring is broken, the sides B are opened. The rivet can be removed by filing the sides of the round head and then pushing the head through the hole; the metal guard is placed over the rivet to protect the wood during the filing operation. The rivet is drawn out, the broken spring removed, and the new spring put in.

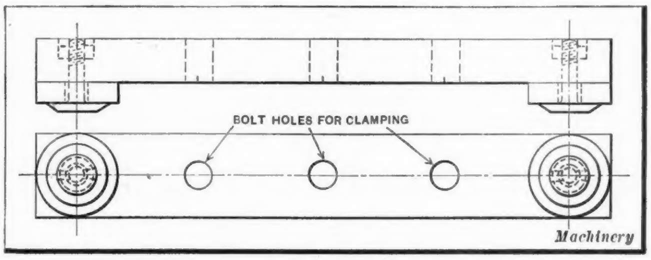


Method of mending Broken Folding Rule

Kenosha, Wis. M. E. DUGGAN

ADJUSTABLE SINE BAR

A few years ago the sine bar was unknown, but today it is used in the toolmaking departments of all up-to-date shops;



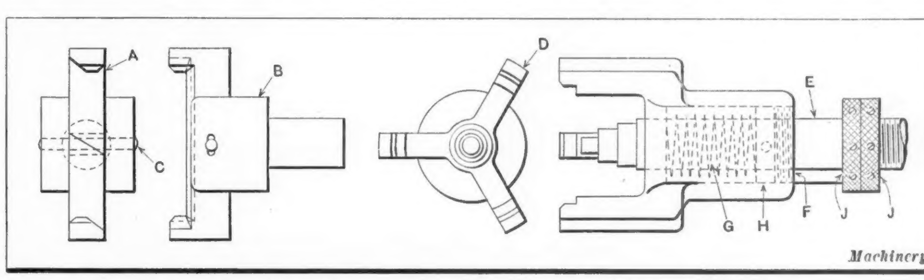
Adjustable Sine Bar

it has been instrumental in arousing the toolmaker to a more diligent study of the mathematics of his trade. The bar here shown was devised to make unnecessary the boring or grinding of the two holes an exact distance between centers. One-inch micrometer test pieces are used for buttons. The bar is 6 inches long, ½ inch thick, and 1 inch wide, which gives a 5-inch center to center distance. The bolts are smaller in diameter than the holes in the buttons, so that the buttons can be shifted to allow for any inaccuracy in drilling the holes and make the center distance exact. It is possible that the buttons may be displaced in use, so it is desirable to test them before using. Another advantage of this design is that the bar can be easily reground when damaged.

Bridgeport, Conn. E. P. Davis

TOOLS FOR MACHINING CARTRIDGE CASES

Munition manufacture has brought into play considerable inventive genius and ingenuity, for obstacles have arisen in tooling which at first appeared to be insurmountable. One of the great difficulties encountered has been the inability of the manufacturers to obtain tools that would continuously and accurately perform the work, called for by the excessive speed of production, within the close limits of accuracy to which the finished product had to be held.



High-speed Sizing Cutter and Pilot Reamer for machining Cartridge Cases

The machining operations on a cartridge case, whether French, British, Russian or Italian, are: machine face, form head, cut to length, drill primer hole, thread primer hole, finish-turn head diameter, and finish-ream primer hole. The first operation is performed by means of a round-nose tool mounted in an adjustable tool-holder on the cross-slide, which permits the tool to be drawn away from the face of the cartridge case upon the return stroke of the cross-slide. The second operation is performed by means of a circular forming tool mounted on the end of the adjustable tool-holder, and held by a left-hand threaded stud, which prevents the tool from working loose. The case is cut to length by a V-shaped finishing mouth tool and the primer hole is formed by a twist drill, which is used in preference to a flat-nose drill. A collapsible threading die-holder, equipped with interchangeable thread chasers, is used for threading the primer hole.

In the sixth operation a hardened and ground high-speed sizing cutter *A* is used. This cutter, which is held in holder *B* by pin *C*, is an adaptation of the Kelly reamer, as it permits the cutter to "float," machining the high spots from the head of the cartridge case by utilizing the old principle of centrifugal force.

The final operation—finish-reaming the primer hole—is the one that calls for the greatest accuracy. The reamer *E* is held in a pilot *D* and the depth of cut is regulated by screw collars *J*. The machining operation is as follows: The pilot *D* engages the head of the cartridge case to which it is adjusted by means of the adapter carried in the turret. Then collars *J* are adjusted to permit the reamer to cut to the proper depth. A spring *G*, held in place by collar *H* on reamer *E*, maintains a constant pressure on pilot *D* and keeps it in contact with the face of the cartridge case. As the reamer enters the primer hole and performs its operation, collars *J* are brought into contact with pilot *D*, which acts as a positive stop. By using these two tools, the most unskilled operator will produce satisfactory work.

Chicago, Ill. Fred. H. Korff

BONUSES

My experience with bonuses is that most employes would rather have $5 a month than $100 at the end of the year. The relation is the same as that existing between the trophy cup actually displayed in a shop window before a race and one promised to be made after the event; the visible, immediate reward is the greater stimulus. I would, therefore, recommend paying employes' bonuses monthly, or at least quarterly. As regards minors' bonuses, I have found that in those cases where parents take all the minors' earnings, the latter have no inducement to increase their output. If they are given a daily or weekly "stunt," and allowed to go when that is accomplished, they get through an hour or so ahead of the usual closing time. When they work independently and not progressively in groups or teams, passing work from one to the other, it enables more rapid manufacture, mailing, delivery, etc.

New York City Robert Grimshaw

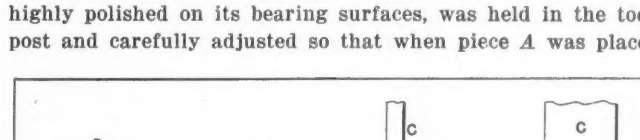
BUILT-UP SNAP GAGES

The long lower jaw of the built-up snap gage shown in the March number of Machinery does not seem to be as well supported as it should be. The illustration shows the long jaw resting on two bosses of the central piece, with two of the four holding screws passing through the space between the end bosses. It stands to reason that when the screws are tightened the long jaw will be sprung and the measuring ends thrown outward, making the gage inaccurate. The obvious remedy is to put a pad between the two middle screws that is wide enough to reach them both.

St. Louis, Mo. Louis A. Schlossstein

ECONOMICAL METHOD OF MAKING STEEL PINS

A recent order for several thousand machine steel pins *A*, taken at a low figure, made it necessary to get the pieces out as cheaply as possible without sacrificing quality. These are made of ⅝-inch, cold-rolled stock and are cut to length by a power hacksaw. The piece is then turned to size on the ends and the large part is ground on a No. 11 B. & S. plain grinder. To center the pieces, a female center *B* was made for a small lathe that had been discarded, being considered worn out; this was then hardened and ground so as to run perfectly true and a V-shaped steadyrest *C*, hardened and highly polished on its bearing surfaces, was held in the tool-post and carefully adjusted so that when piece *A* was placed

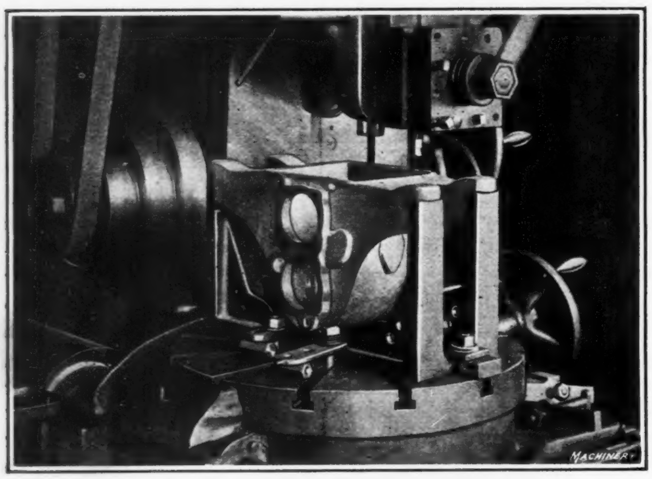


Quick Method of making Steel Pins

in the position shown, the end E was central with a countersink D held in the tailstock. The female center B runs continuously; so, to center the piece, one end is placed in the center and the other end in the steadyrest C, where it is held with the fingers while the countersink is fed forward. The friction of the end of the piece on the center is sufficient to allow a good center to be drilled. As there is no shifter to operate or chuck to open, the operation is fast and accurate, running within 0.004 inch of being true. This method of centering has also been used on other work where a small amount of stock was to be removed, and it has been found very satisfactory and economical. J. F. S.

MACHINING TRANSMISSION CASES ON VERTICAL BORING MACHINE

The illustration shows a job that is usually done on a vertical milling machine. But where there is no other work to do on the face, that is, where all the surfaces to be machined are at the same level, the boring mill beats the milling machine two to one. With a single-pointed tool held as shown,



Machining Transmission Case on Vertical Boring Machine

a transmission case can be turned off in three minutes, including setting and removing from the machine; in a vertical milling machine the best time is about six minutes. The work from the boring mill is also much smoother than that from the milling machine. With the jig shown, only two clamps are necessary to hold the work, one on each side in the lower holes; these clamps are not shown, the ones shown being those used to hold the jig in place. ROBERT MORRIS

MILLING THE TAPERING SIDES OF A BAYONET

Nothing unusual would be noticed by a casual glance at the dimensions of the bayonet shown in Fig. 1. But should a person be given this bayonet to machine, he would find that there was a pretty little problem to be worked out in milling the front, or cutting edge, of the blade. It will be noticed that there are two thicknesses of the blade, as shown in sections A and B, and it is with the surface that lies between these sections that the problem is found. In Fig. 2 is shown an enlarged view of this surface; the dimensions given are

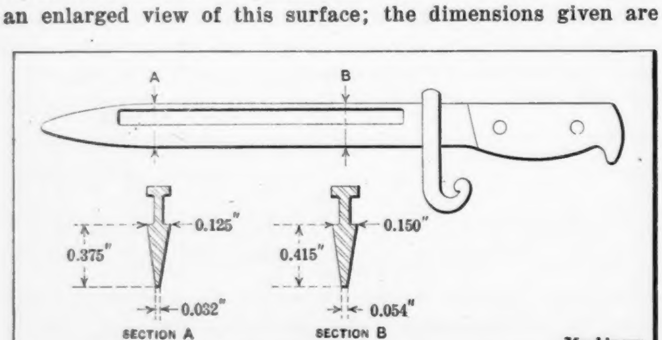


Fig. 1. Side View and Sections of Bayonet

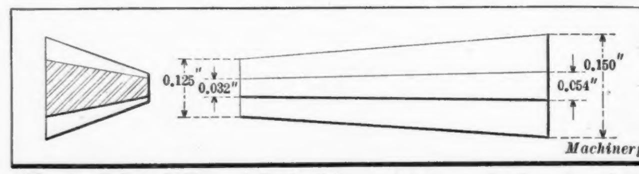


Fig. 2. Enlarged View of Part of Bayonet between Sections A and B, Fig. 1

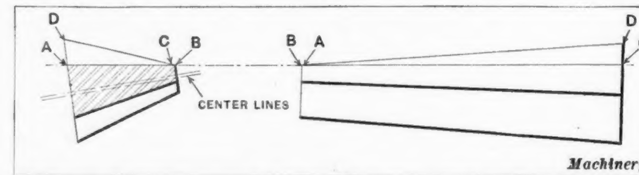


Fig. 3. Diagram showing why Bayonet cannot be milled at a Plain Taper

identical with the dimensions of the cutting blade shown in Fig. 1. It might appear, offhand, that the angular sides were straight surfaces and could be milled with a straight faced cutter, but Figs. 2 and 3 show that this is not so.

Figs. 1 and 2 convey the impression that the two sides of the blades are tapered and merely connect four points. But upon attempting to set the work up to mill it is found that, although the work can be tipped around to bring the three points A, B, and C, Fig. 3, in line for plain milling, the fourth point D cannot be brought into the same plane if the center lines of the two ends are kept parallel; and if the center lines are not parallel the work is being bent to conform to the requirements which, of course, should not be done. As it is necessary, when milling these surfaces with a flat-faced cutter (whether this cutter is angular or a plain surface mill) to turn the work as in spiral milling in order to connect the four points, it follows that these surfaces are spiral.

The writer was recently up against the proposition of milling these surfaces without resort to spiral milling, and adopted

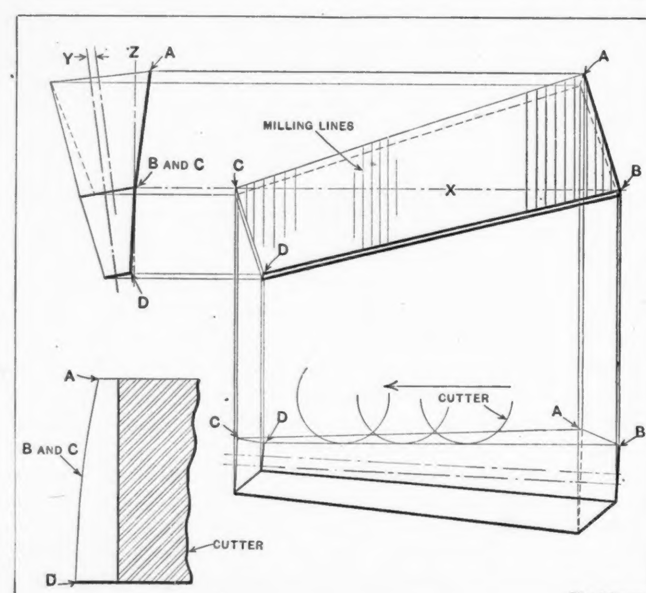
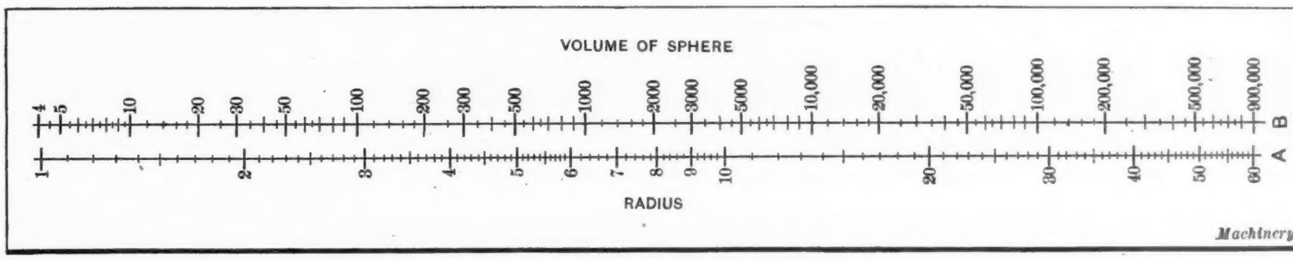


Fig. 4. Section of Blade in Milling Position

the method shown in Fig. 4, although it did not give a perfect surface. Point B was swung around until it came in line with point C, as indicated by line X. This, in itself, was not sufficient, so point C was raised until it came in line with point B, as indicated by line Z. In doing this, the center lines through a section taken at both ends were parallel, thus proving that the work was not distorted. With the work in this position, a block was made to conform to the shape of the under side, and the work was placed on it. In making the cut, with the cutter traveling in the direction of the arrow, the metal at point B is the first to come in contact with the cutter; this actually leaves a concave surface at any one point, but this concave, as it worked out, was very slight. Although only four points have been taken into consideration by the description, points taken anywhere along the lines shown will vary from the true form in the same proportion. F. M.



Handy Chart for determining Volume of Sphere

DIE FOR ASSEMBLING ASH-PAN HANDLES AND BODIES

Fig. 1 shows a portion of the top view and cross-section of an ash pan, with handle inserted, as used in steel ranges. At *M*, Fig. 2, is shown the 3/16-inch round wire handle as it comes from the bending die. This illustration also shows the die for turning back the ends of the handle after it has been inserted in the end of the ash pan. Its operation is as follows: Levers *A*, which are pivoted at points *B* and held together by a light coil spring *C*, are spread apart by turning cam *D*. The wire handle *M* is then inserted in groove *E* and cam *D* turned, so as to allow levers *A* to swing back into place and hold the handle firmly in the upper die; the ends of the handle project about 5/8 inch below the lower surface of the die. The ash pan is then pushed in from the front of the press and lifted up to meet the upper die, holes having been punched in the end of the body to match the ends of the handle. The press is then tripped, and as the ram descends, the ends of the wire handle are forced down into grooves *G* of levers *H*, which are pivoted at point *J* and held up by pins that pass down to a plate on the under side of the lower die. This plate is held in place by a heavy coil spring, as shown. When the down stroke has been completed, levers *H* rest on the body of the lower die and the ends of the wire handle have been carried outward and upward so that they are bent in opposite directions and at right angles to their first positions. The work is removed by turning cam *D*. Holes *K* are drilled to match stud bolts in the ram of the press. The levers *H* are of steel and bronze bushed.

Beaver Dam, Wis. S. W. PALMER

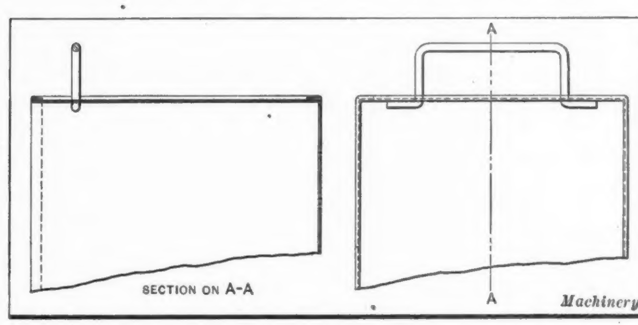


Fig. 1. Part Top View and Cross-section of Ash Pan

HANDY CHART FOR DETERMINING VOLUME OF SPHERE

The accompanying chart will be found handy for determining the volume of any sphere. Column *A* gives the radius of the sphere and column *B* the corresponding volume. By referring to the chart, it will be seen that the volume of a sphere with a radius of 10 inches is about 4200 cubic inches. If the radius is given in millimeters, the volume will be cubic millimeters; if in feet, the volume will be cubic feet.

Inversely, if it is desired to find the radius of a sphere when the volume is known, it is simply necessary to glance across from column *B* to column *A*. For example, the radius of a sphere having a volume of 20,000 cubic centimeters is found, by reference to the chart, to be a trifle less than 17 centimeters.

Attention is called to the fact that when the radius is 50 the volume is close to 500,000, and when the radius is 5 the volume is 500. There are three digits more in 500,000 than in 500, and one digit more in 50 than in 5. Thus it will be understood that the decimal point is shifted three places to the right in column *B* when adding a digit in column *A*. Similarly, if the decimal point is moved one place to the left in the figures in column *A*, the decimal point must be moved three places to the left in column *B*. For example, we can find the volume of a sphere with a radius of 0.2 inch by referring in column *B* to the volume for a sphere of 2-inch radius and moving the decimal point three places to the left; this gives 0.033 cubic inch. These examples could be carried further, but those given are sufficient to indicate that the range of the chart is limitless.

N. G. NEAR

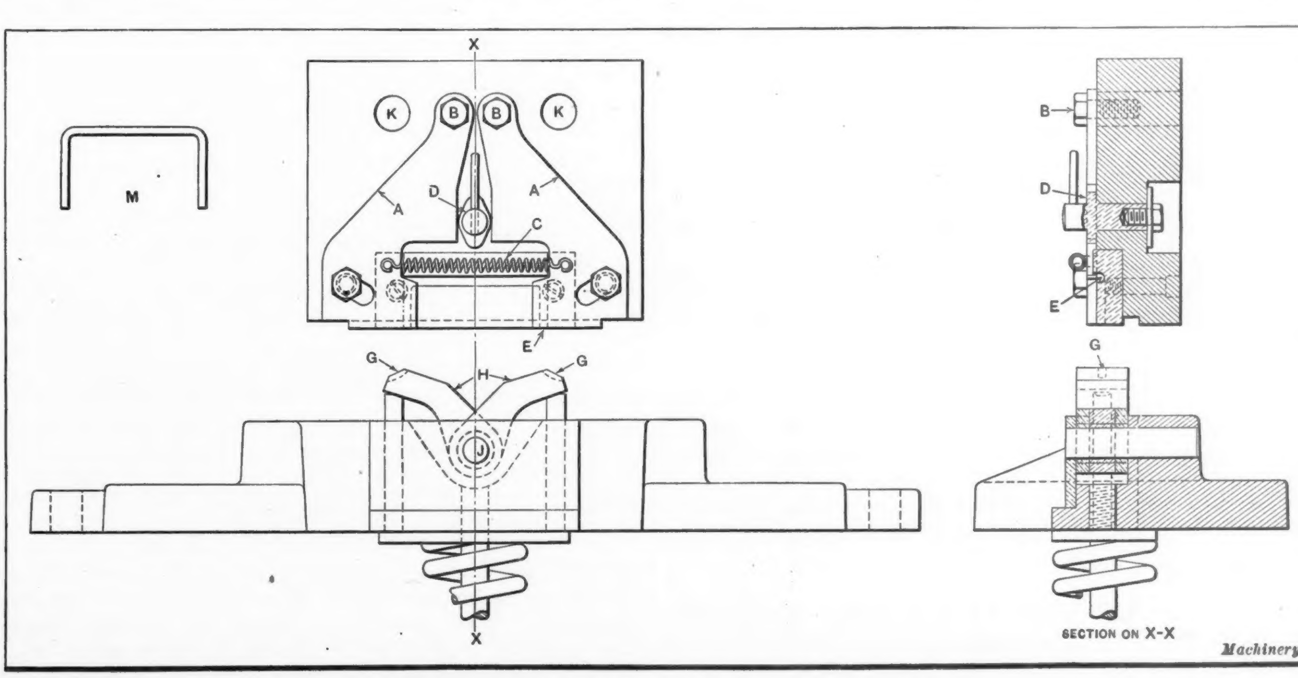


Fig. 2. Die used for turning back Ends of Ash-pan Handles

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

AUTOMATIC SCREW MACHINE STOCK

B. F. E.—Can you tell me what are the physical characteristics of free-cutting screw machine steel stock?

A.—The National-Acme Mfg. Co., Cleveland, Ohio, a large manufacturer of screw machine products, specifies Bessemer screw stock having a tensile strength of 70,000 to 80,000 pounds per square inch.

HAND OF MACHINE PARTS

C. F. T.—Will you kindly give your opinion of the following sentence: "The polishing head carries a taper on the right-hand end of the spindle." Should there be any confusion as to which end of the spindle is meant, making it necessary to say the right-hand end of the spindle when facing the machine?

A.—The hand of machinery parts is fixed with reference to the operator. The parts that are on his right are the right-hand parts, and those on the left, the left-hand parts. Hence the meaning of the sentence given should be perfectly clear.

DRILLING DEEP HOLES IN STEEL DIES

C. J. B.—I would like advice on how to drill holes varying in diameter from 0.120 to 0.385 inch, about 4 inches deep, in steel heading dies. The holes must be straight and smooth, and within limits of $\pm$ 0.001 inch. What kind of drills and reamers should be used and what is the proper lubricant? I have these dies to drill in lots of 100 to 500, and it is essential that the method be fairly rapid and productive of good results.

The question is submitted to readers having had experience in this class of work.

FACING THE ENDS OF SHAFTS BEFORE TURNING

J. U.—Will you kindly decide the following question: A claims that if a shaft is to be turned on centers in a lathe, the ends must be squared; if they are not squared, the shaft will run out after taking facing cuts. B claims that if a shaft is centered properly, it does not matter whether the ends are square or not; the shaft after turning must be true.

A.—The rule is always to face the ends of a shaft after centering and before turning, because an uneven end is likely to cause the shaft to change position slightly on the center when faced off. It is not necessary, however, that the entire end of the shaft be faced; if trued around the center, the shaft will not change position when the ends are faced.

POSITION OF ANVIL AND VISE

G. H. G.—How should a blacksmith's anvil be set—with the horn at the right or left of the blacksmith? How should a machinist's vise be set on the bench in relation to the tool drawer and the workman's allotment of the bench space?

A.—A blacksmith's anvil should be set in relation to the forge so that the horn will be at the blacksmith's left when he turns around to forge a piece. But if he is a left-handed blacksmith, the horn should be on his right hand, of course. A machinist's vise should be set on the left-hand side of the tool drawer, but his allotment of bench space should not stop at the vise. He should have at least two feet of space on the left of the vise in order to handle conveniently heavy pieces that must be held in the vise. The tool drawer on the right is most convenient for a right-handed man, as he can select tools from the drawer and use them without materially changing his position.

DIRECTION OF SPIRAL OF END MILLING CUTTERS

A. F. S.—Will you please advise me regarding the use of spiral end milling cutters up to 1½ inch diameter as to whether a right-hand or a left-hand spiral should be used with a right-hand cutter? Some mechanics tell me to use a right-hand spiral, while others claim that less breakage results from cutters with left-hand spiral flutes.

A.—Theoretically, a right-hand cutter should have right-hand spiral flutes, as the teeth then have positive rake. It is true, however, that the right-hand flutes tend to pull the cutter out of the socket when used for side milling, and cause breakage. But this disadvantage should not be allowed to outweigh the advantage of having the cutter teeth made with positive rake. It is good practice to provide means for holding the cutter firmly in the socket, as has been done by some of the leading milling machine manufacturers who provide a screw collet for the end of the cutter shank (threaded to fit), and means for drawing it firmly into the spindle socket.

SOLVING SPECIAL CASES OF RIGHT TRIANGLES

C. W. M.—Referring to the illustration, ABC is a right triangle, right-angled at C. If the side a and the sum of the other two sides are known, how can the lengths of c and b be found? Also, if c and the sum of a and b are known, how can the lengths of a and b be found?

A.—For the first case, let $s = c + b$, then $b = s - c$. But $c^2 = a^2 + b^2$. Substituting the value of b, $c^2 = a^2 + s^2 - 2cs + c^2$, or $2cs = s^2 + a^2$. Therefore, $c = \frac{s^2 + a^2}{2s}$. For example, suppose $c + b = 20$ and $a = 5$, then $c = \frac{20^2 + 5^2}{2 \times 20} = 10.625$, and $b = 20 - 10.625 = 9.375$.

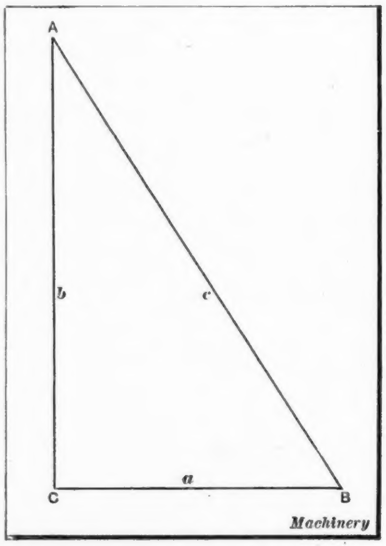


Diagram illustrating Special Solutions of Right Triangles

For the second case, let $a + b = s$, then $a = s - b$. But $c^2 = a^2 + b^2$. Substituting the value of a, $c^2 = s^2 - 2sb + b^2 + b^2$. Transposing, combining, and reducing, $b^2 - sb = \frac{c^2 - s^2}{2}$; whence, $b = \frac{1}{2}(s + \sqrt{2c^2 - s^2})$. If the $+$ sign is used, the length of the longer side will be obtained; and if the $-$ sign is used, the length of the shorter side will be found. For example, if $c = 10\frac{5}{8}$ and $a + b = 14\frac{3}{8}$, $b = \frac{1}{2}(14\frac{3}{8} \pm \sqrt{2 \times 10.625^2 - 14.375^2}) = \frac{1}{2}(14.375 \pm 4.375) = 9.375$, or 5; that is, the longer side is 9.375 and the shorter is 5.

J. J.

RATING OF PUNCH PRESSES

C. E. T.—What rules, if any, can be followed in rating punch presses? The ratings given by the various makers do not seem to agree, but inasmuch as the principle of operation is the same in all, there must be some agreement in the actual productive rating of presses built by the principal makers.

A.—The capacity of punch presses is an important matter, but, unfortunately, it is practically impossible to reconcile the ratings given by the various makers with the weight and dimensions of the presses. However, the following suggestions made by a press expert may be found valuable: There is little connection between the number of a press and its tonnage capacity, although some makers have employed the

system of expressing tonnage as the square of the number of the press. A better rule, perhaps, is to compute the tonnage by the weight of the press. In the case of most straight-side or pillar presses the weight of the press in pounds divided by 80 will give the capacity of the press in tons. On overhanging presses of ordinary design the weight of the press should be divided by 100 to 120 to obtain the tonnage. For example, the tonnage of a straight-side press weighing 5600 pounds is $5600 \div 80 = 70$ tons, which is approximately correct. In the case of an overhanging press weighing, say, 3200 pounds, with an average depth of throat of about 7 inches, we have $3200 \div 100 = 32$ tons capacity, which also is close to the correct figure. On small overhanging presses the weight of the flywheel divided by 16 gives the tonnage of the press closely, but on large presses weighing 2500 pounds or more, the weight of the flywheel is divided by 20 in order to get the approximate tonnage. The crank-pin may also be used to determine the capacity of the press, taking the square of the diameter and multiplying it by 3 to $3\frac{1}{2}$. The cross-section of both uprights of the frame of straight-side presses, in square inches, multiplied by one ton per square inch gives a close approximation to the safe working tonnage of the press. Of course the foregoing rules are empirical and their usefulness depends on the presses to which they are applied being made in close conformity to designs that have given general satisfaction in use.

PROBLEM CONCERNING VIRTUAL VELOCITIES

P. G. P.—The illustration shows a flywheel with an axle 2 inches in diameter; as the flywheel turns, it winds up a rope on the axle, and thus raises a weight as shown. If the kinetic energy of the flywheel is 5000 foot-pounds, it will raise a weight of 2500 pounds 2 feet when the diameter of the axle is 2 inches; will it raise the same weight 4 feet if the diameter of the axle is 1 inch?

A.—The flywheel will raise a weight of 2500 pounds 2 feet in each case; the diameter of the axle or drum has nothing to do with the case. According to the law of virtual velocities (see MACHINERY for June, 1916, page 897), the power multiplied by the distance through which it moves is equal to the weight multiplied by the distance through which it moves. This law is really a statement of the law of work and energy. The energy of the flywheel is exactly equal to the work expended in enabling it to store up this energy; hence, the power multiplied by the distance through which it moves = 5000 foot-pounds = the weight multiplied by the distance through which it moves = 2500×2. It will thus be seen that it does not matter how the load is raised (neglecting friction and other resistances); all that we are concerned with is the number of pounds that the load weighs and the height through which it is raised. J. J.

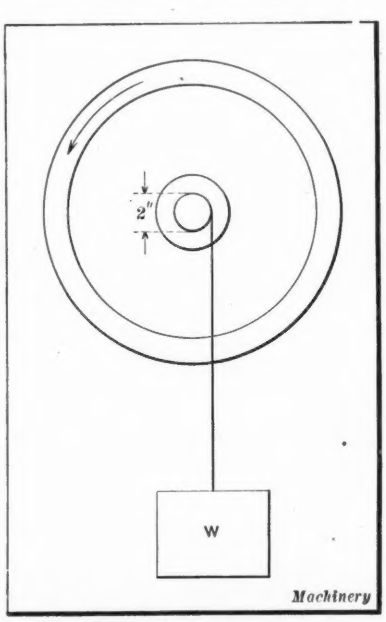


Diagram illustrating Virtual Velocities Problem

FINDING RADIUS OF CIRCLE

F. P. J.—Referring to the illustration, ABC is a right triangle, right-angled at B. With the dimensions given, it is required to find the radius of a circle that will pass through points C and E and be tangent to the side AB. Four of us have tried this and each has obtained a different result.

A.—First calculate the distance DB, which evidently equals $BC \times \cot 23$ degrees $- DE \times \cot 23$ degrees $= (5.1 - 3.8) \cot 23$ degrees $= 1.3 \times 2.355852 = 3.062608$. Through the center O, draw OH parallel and FG perpendicular to BC, and draw OE and OC. Let r be the radius; then $OF = \sqrt{r^2 - FE^2} = \sqrt{r^2 - (3.8 - r)^2} = \sqrt{7.6r - 14.44}$. Whence, $OG = DB - OF = 3.062608 - \sqrt{7.6r - 14.44}$. $CG = 5.1 - r$. Hence, $OC^2 = OG^2 + CG^2 = (3.062608 - \sqrt{7.6r - 14.44}^2) + (5.1 - r)^2 = r^2$. Squaring and transposing and combining terms, $20.949568 - 2.6r = 6.125216\sqrt{7.6r - 14.44}$. Squaring again, transposing, and combining terms, we obtain the quadratic equation $6.76r^2 - 394.076338r + 980.648296 = 0$. This equation may be solved in the regular way, but much more easily by Horner's method; whatever method is used, however, $r = 2.604869$ inches. It is always well, in cases of this kind, to check the work. Had you and your friends done this you would have known which was right. Here, $OF = \sqrt{7.6r - 14.44} = \sqrt{7.6 \times 2.6049 - 14.44} = 2.3145$; $CG = 5.1 - 2.6049 = 2.4951$; and $OG = 3.0626 - 2.3145 = 0.7481$. $OC = r = \sqrt{2.4951^2 + 0.7481^2} = 2.6049$, as before. J. J.

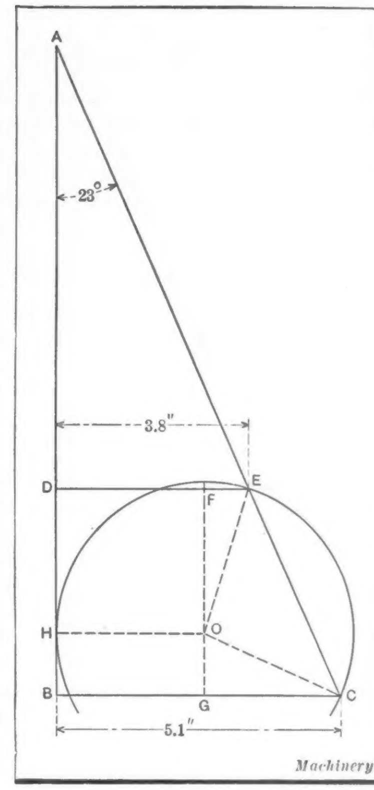


Diagram for finding Radius of Circle

MEASURING FORMING TOOL BY WIRE METHOD

J. F.—A forming tool of the shape indicated in Fig. 1 is to be made. Angles α and β are known, as well as the diameter of the wire, which is $2r$, and dimension b. What is the formula for finding dimension c measured over the wires, in order to insure that dimension b is correct? It is assumed, of course, that the angles are accurate. In a specific example, α equals 35 degrees, β equals 40 degrees, 36 minutes; the diameter of the wires is 3/16 inch; and dimension b is 2 inches.

A.—In order to determine the dimension c measured over the wires, it is necessary first to determine dimension a. It is evident that $2a + 2r + b = c$. In order to determine a, draw construction lines as shown in Fig. 2. Here line AD equals a. The center of the wire is at C. Line CB is at right angles to AB. Line AC, passing through the center of the circle, which is tangent to lines AE and AB, divides angle BAE into two equal parts; hence, angle $BAC = \frac{\alpha + \beta}{2}$. Angle $CAD = \beta - \frac{\alpha + \beta}{2}$, which, simplified, may be written, $\frac{\beta - \alpha}{2}$. Further, $BC = r$.

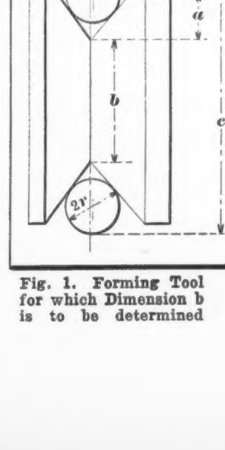


Fig. 1. Forming Tool for which Dimension b is to be determined

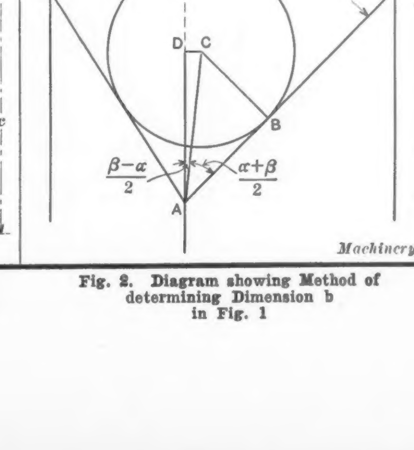


Fig. 2. Diagram showing Method of determining Dimension b in Fig. 1

Now, we find directly by the rules for right-angle triangles:

$$AC = r \div \sin\frac{\alpha+\beta}{2}, \text{ and } AD = AC \times \cos\frac{\beta-\alpha}{2}$$

Having thus found AD, which equals a, the problem is solved. Inserting the given values in the formulas, we have:

$$AC = 3/32 \div \sin 37 \text{ deg., } 48 \text{ min.} = 0.15296$$

$$AD = 0.15296 \times \cos 2 \text{ deg., } 48 \text{ min.} = 0.15278 = a$$

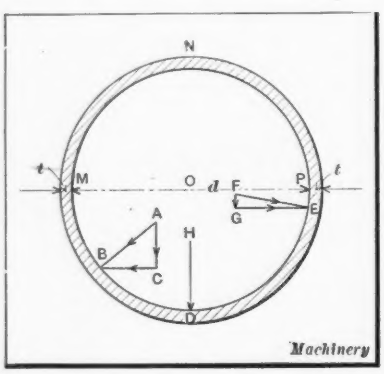
Hence, $c = 2 \times 0.15278 + 3/16 + 2 = 2.4931.$

THICKNESS OF A CYLINDRICAL SHELL

L. W. N.—Will you please explain fully how the formula for finding the thickness of a cylindrical shell that is subjected to internal fluid pressure is derived?

A.—For convenience, assume that the fluid is steam or gas (say compressed air) and that its tension (pressure) is p pounds per square inch. Denote the length of the cylinder by l, the thickness of the shell by t, and the interior diameter by d. The illustration represents a cross-section perpendicular to the axis of the cylinder, and we shall suppose further that it represents a ring 1 inch wide. According to Pascal's law, the pressure at any point is always perpendicular to the surface at that point; consequently, it is always radial, as indicated by the arrows AB, HD, and FE, which represent the pressure p on a unit of area at B, D, and E, respectively. If the pressure is great enough, it will separate one-half of the shell from the other half; suppose it separates the upper half MNP from the lower half MDP. Since the forces acting downward are equal and opposite to those acting upward, it will suffice to determine the downward pressure. At D the unit pressure acts entirely downward; at B it can be resolved into two components, one AC acting downward, and the other CB acting horizontal. As M and P are approached, the downward pressure becomes less and less, and when M (or P) is reached it becomes 0. By methods of the calculus, it is easily shown that the total downward pressure on the strip is $p \times d$, and on the shell it is $p \times d \times l$. This pressure is resisted by the strength of the material of the shell multiplied by the area of the ruptured surface, or $2t \times l \times S$, in which $2t \times l$ is the area in square inches (l being the length in inches) and S is the ultimate strength in pounds per square inch. Therefore, $2tSl = pdl$, or $t = \frac{pd}{2S}$. This formula presupposes that t is small, compared with $r = \frac{d}{2}$, and that l is large, compared with r. The formula may be solved for p, giving $p = \frac{2tS}{d} = \frac{tS}{r}$. If t is greater than $0.1r$, or $\frac{r}{10}$, it is best to use the following formulas: $p = \frac{tS}{r+t}$ and $t = \frac{pr}{S-p}$. It is best to calculate t by the first formula, and then, if it is greater than $0.1r$, recalculate it by the second formula. In practice, S should always be divided by the proper factor of safety before it is substituted in any of the foregoing formulas.

J. J.



Cross-section of a Cylinder

FORMULA FOR RADIUS WHEN CHORD AND LENGTH OF ARC ARE GIVEN

C. W. M.—I should like a formula for finding the radius when the length of the arc and its chord are given. I am unable to find such a formula in any of my reference books.

A.—The writer has never seen such a formula, but one may easily be derived as follows: Let r = radius, C = chord, L = length of arc, and ϕ = central angle, in radians. Then $L = r\phi$, from which $r = \frac{L}{\phi}$, and $\frac{C}{2} = r \times \sin\frac{\phi}{2} = \frac{L}{\phi} \times \sin\frac{\phi}{2}$, or $\sin\frac{\phi}{2} = \frac{C\phi}{2L}$. Now we know from trigonometry that $\sin x = x - \frac{x^3}{6} + \frac{x^5}{120} - \frac{x^7}{5040} + \text{etc.}$ Substituting $\frac{\phi}{2}$ for x in this expression, $\sin\frac{\phi}{2} = \frac{\phi}{2} - \frac{\phi^3}{48} + \frac{\phi^5}{3840} - \frac{\phi^7}{645120} = \frac{C\phi}{2L}$, very nearly. Transposing the right-hand member, clearing of fractions, and dividing through by ϕ, $\phi^6 - 168\phi^4 + 13440\phi^2 - 322560\left(\frac{L-C}{L}\right) = 0$. From this equation, ϕ may be found by Horner's method; then, knowing ϕ, $r = \frac{L}{\phi}$. This equation gives exact values for ϕ for all angles. For a semicircle, $L = 3.1416$ to a radius 1, and $\phi = 3.1413$, as calculated by the formula. For angles not greater than 90 degrees, a simpler expression may be obtained by dropping the term ϕ^6 and dividing through by -168, the coefficient of ϕ^4; the equation then becomes $\phi^4 - 80\phi^2 + 1920\left(\frac{L-C}{L}\right) = 0$. This last equation may be solved as a quadratic, and we obtain $\phi = \sqrt{40 - \sqrt{1600 - 1920\left(\frac{L-C}{L}\right)}}$. For 90 degrees and a radius 1, $L = 1.5708$ and $\phi = 1.5712$, as calculated by the formula. For angles considerably greater than 90 degrees, the last formula does not give very close results. For example, for 120 degrees, $L = 2.0944$ and $\phi = 2.0960$; for 180 degrees, $L = 3.1416$ and $\phi = 3.1562$.

J. J.

MOMENT OF INERTIA OF A SECTION

G. F. L.—Will you please tell me how to find the moment of inertia of a section like the one shown in the illustration?

A.—We assume that you wish the moment of inertia about the axis X'–X, which passes through the center of gravity of the rectangle $ABCD$ and is perpendicular to the long side AD. The following principle is demonstrated in works on mechanics: The moment of inertia of a section about any axis is equal to the moment of inertia about a parallel axis through the center of gravity plus the product of the area of the section by the square of the distance between the axes. Let I = the required moment of inertia; I_1 = moment of inertia about a parallel axis through the center of gravity; A = area of section, and h = perpendicular distance between the axes. Then $I = I_1 + Ah^2$. If the given area is divided into sections of such shape that their areas, A_1, A_2, A_3, etc., the distances of their centers of gravity from the given axis, h_1, h_2, h_3, etc., and their moments of inertia, I_1, I_2, I_3, etc., may be calculated, then $I = I_1 + A_1h^2_1 + I_2 + A_2h^2_2 + I_3 + A_3h^2_3 +$ etc. It is possible to proceed in several ways. Thus, assume that the given section is made up of the following: two rectangles 1 inch by 10 inches, two rectangles 5 inches by 1 inch, one rectangle ½ inch by 8 inches, and two rectangles 2¼ inches by ½ inch. For the first and third sets, the centers of gravity lie on the axis X'–X, and h_1 and h_3 are both equal

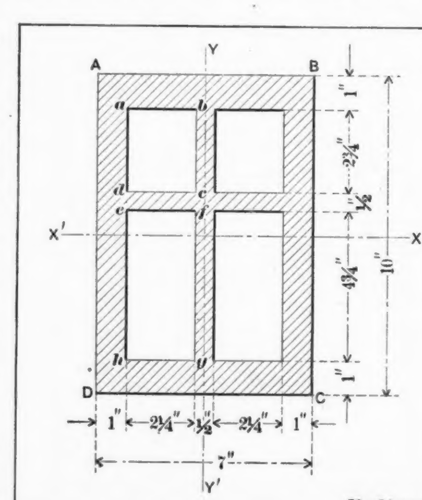


Diagram illustrating Method of finding Moment of Inertia of a Section

to 0; for the second set, $h_2 = 4\frac{1}{2}$ inches; and for the fourth set, $h_4 = 1$ inch. Since the moment of inertia of a rectangle is $\frac{bd^3}{12}$, when the axis passes through the center of gravity parallel to the base, and b is the breadth AB and d is the depth AD, $I =$

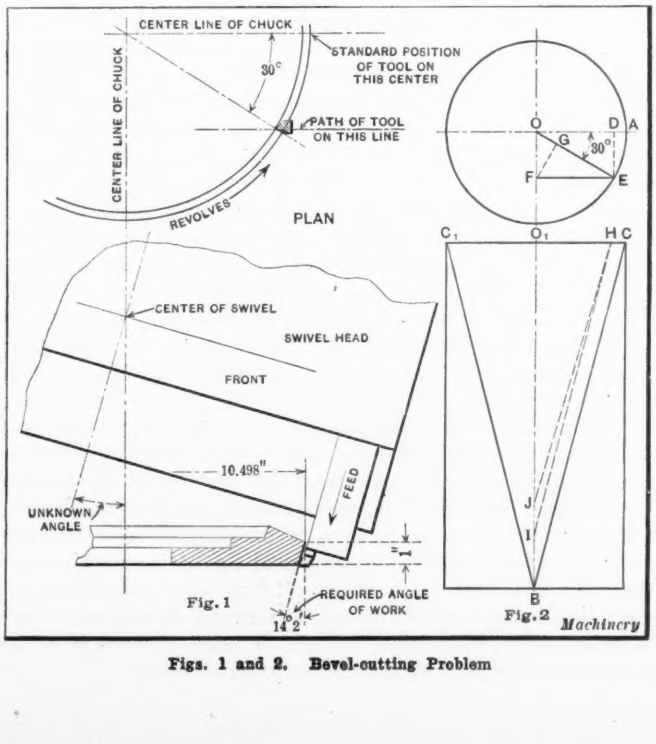
$$\frac{1 \times 10^3}{12} \times 2 + \left[\frac{5 \times 1^3}{12} + 5 \times 1 \times (4\tfrac{1}{2})^2\right] \times 2 + \frac{\frac{1}{2} \times 8^3}{12} + \left[\frac{2\frac{1}{4} \times (\frac{1}{2})^3}{12} + 2\tfrac{1}{4} \times \tfrac{1}{2} \times 1^2\right] \times 2 = 393.63.$$

Another method is to calculate the moment of inertia of the rectangle $ABCD$ and then subtract the moments of inertia of twice the rectangle $abcd$ and twice the rectangle $efgh$, all taken with reference to the axis X′–X. Either method will give the same result. If I is calculated for the axis Y′–Y, what was the breadth of the rectangle becomes the depth, and it will be found that I for Y′–Y is much less than it is for X′–X. It is for this reason that a beam is stronger when the long side is vertical. J. J.

CUTTING A BEVEL WHEN TOOL IS AHEAD OF CENTER

J. W. D.—We have a bevel gear, 10.498 inches outside diameter, with an angle of 14 degrees, 2 minutes from the vertical to be turned on a vertical boring mill having a swivel head. The arrangement of the head is such that to turn this angle, it is necessary to place the cutting tool 30 degrees ahead of center. At what angle must the swivel be set to cut 14 degrees, 2 minutes? Will we get a true straight line on this angle or will it be slightly concave?

A.—The conditions are represented in Fig. 1. Referring to Fig. 2, if the tool were located at A and fed along the line OA at an angle of 14 degrees, 2 minutes to the vertical, it would generate a conical surface, which would be a part of the cone CBC_1, and the path of the tool point would be along the line CB (an element of the cone) in a vertical plane. The tool point, however, is located at E, 30 degrees from A; it moves along the line EF, and does not pass through the axis of the cone. The projection of the path on a vertical plane, the trace of which is OA, is the line HI, which is parallel to CB. The surface so generated will not be conical, but a warped surface, the mathematical name for which is a hyperbolic-paraboloid, and it can always be generated by the movement of a straight line. If a straightedge is laid on this surface extending from C toward B, it will touch the surface in only two points. The only way in which a conical surface can be turned is to cause the tool point to move in the line OE. But, as the vertical movement of the tool is only 1 inch, the difference between the warped surface and the true cone can be neglected in practice. To get the required angle, proceed as follows: $OA = 10.498 \div 2 = 5.249$, the radius. It is now necessary to find what angle in the plane EF will project into an angle of 14 degrees, 2 minutes in the plane OE. $OD = OE \times \cos 30$ degrees $= 5.249 \times 0.86603 = 4.5458 = EF = O_1H$. $EG = EF \times \cos 30$ degrees $= 4.5458 \times 0.86603 = 3.9368$. The projection of the path of the tool point on the plane OE will be along a line in the plane EF, the projection of which on OE is HJ. The distance $O_1J = EG \times \cot 14$ degrees, 2 minutes $= 3.9368 \times 4.0009 = 15.751$. The required angle in the plane EF is now readily determined. Denoting it by ϕ, $\tan \phi = \frac{EF}{O_1J} = \frac{4.5458}{15.751} = 0.28860$, which corresponds to an angle of 16 degrees, 6 minutes the angle to which the swivel should be set. J. J.

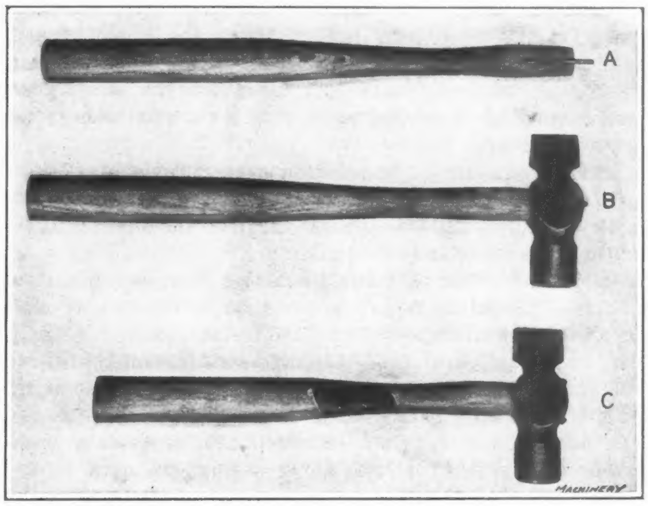


Figs. 1 and 2. Bevel-cutting Problem

* * *

METHOD OF FASTENING HAMMER HEADS

J. H. De Groodt, instructor in shop work at the College of the City of New York, has developed an ingenious device for fastening the head of a hammer securely to the handle. This will best be understood by referring to the illustration of handle A without a head, where it will be seen that the method consists of drilling a hole through the handle in which are placed two nails with the heads cut off and the ends bent over at right angles to enter the hole. Grooves are cut at each side of the handle, in which the nails lie flush with the surface and enable the end of the handle to be inserted in the hammer head in the usual way. The ends of these nails project out beyond the head of the hammer and are bent over, thus securing the hammer head firmly in place. At B the nails are placed in the handle as shown at A; and at C they are placed at the top and bottom of the handle, instead of at the sides. E. K. H.



Method of fastening Heads securely to Hammer Handles

* * *

Owing to the shortage of leather, paper belting is now being used to some extent in Austria-Hungary; it is made chiefly in Bohemia and northern Hungary. The belting is woven from paper cord, which is being used almost entirely in that region. The paper cord is ordinary wood-pulp paper, cut into reels, which is run by means of spinning machines through a paraffin bath and then into strands which are twisted into cordage or twine. Pulp obtained from fir or pine trees is the most satisfactory for this purpose. In order to increase the tensile strength of the cords hemp threads or wire is frequently added to the pulp. The resistance of paper belting to traction is said to vary from 22 to 220 pounds, depending on its quality. When moist the belting loses practically all its tensile strength, and when thoroughly wet will not resist even slight tension. However, the belting may be strengthened by various processes, according to the quality of the cord and to the weaving texture, but it does not attain the strength of leather belting. The abrasion on the cord is much greater than on leather and considerably diminishes its durability.

AMERICA IN WAR

The strength of a country in war is measured by its industrial resources. The ability merely to make guns, shells, rifles and cartridges is by no means the ultimate measure. A country, to be successful in modern war, must be able to coordinate and direct all its industrial resources for the one great purpose of delivering irresistible blows. Germany is united for offensive and defensive purposes. Its industries are under governmental control and are so directed that the maximum productive capacity required for war needs is obtained. We shall be strong in proportion to our capacity to marshal our industrial activities and direct them toward the accomplishment of the purpose to which we are committed. If there is lack of coordination, there will be waste, confusion and futility of purpose. The advisory committee of the Council of National Defense has taken a census of over 27,000 plants, large and small, engaged in the manufacture of the necessities and luxuries of life. These data have been indexed and filed for reference in Washington, the purpose being in an emergency like this to apportion to selected plants the production of machines and supplies for which they are best fitted by reason of equipment, organization and location. The compilation of these data during the past two years has, in a measure, prepared manufacturers and their workmen for this great emergency when individual ownership must surrender to national needs.

Patriotism should be revealed in a practical way. One of the most valuable services that a citizen can render to his country is to produce the things required for subsistence or war in a time like this. Enlisting and training an army are the visible activities that stir the nation's pulses. But these military duties alone do not produce shells, clothing or food, nor provide for transport. These are the problems of the engineer, and require careful planning, investigation and direction, and hard work. The needs of armies are as varied as the needs of humanity in time of peace. There is scarcely a raw or a manufactured product that will not be needed in one way or another; hence, it is apparent that the data secured by the work of the Council of National Defense should, if properly used, be of great value to those who must direct the industrial energies.

The consensus of opinion seems to be that the United States can take but a small part immediately in waging war in Europe because of the lack of shipping to transport supplies. It is estimated that not less than eight tons of shipping will be required to maintain every American soldier in France. An army of 500,000 soldiers on foreign soil, then, would require the use of 4,000,000 tons of shipping to supply their needs alone. The important part that we can take is that of furnishing food and manufactured products at reasonable prices. War has been made the excuse for extortion, and we are now suffering from the effects of inflated prices on every side. Governmental authorities must lay a heavy hand on the bloodsuckers who would fatten on the desperate needs of the peoples at war for principles. Manufacturers and their engineers should endeavor with all their might to restrict costs and limit profits. Their workmen will then in general be willing to work also for the common good and forget for the time to demand higher wages and shorter hours.

Thanks to the contracts for munitions that came to the United States in the early days of the war, we are by no means without experience. It is estimated that the daily productive capacity of the plants making shells and that have filled shell contracts is equivalent to not less than 300,000 three-inch shells daily. The great rifle factories at Bridgeport, Ilion, Eddystone and Chicopee, which did not at first succeed in organizing on an efficient basis for the manufacture of military rifles, are now on a sound footing; the productive capacity of all the plants now making military rifles in the United States is about 15,000 rifles daily.

When Great Britain declared war in August, 1914, it was a great commercial and industrial nation, but its plants were inadequately organized and there was no common purpose. Manufacturing had been carried on without a proper and full comprehension of the value of gages, jigs and fixtures and the importance of interchangeability of parts made in large quantities. The making of the thousands of gages required for the manufacture of shells alone was an enormous task, and few outside of the munitions work realized the importance of gage manufacture for this one branch of military activity.

The United States government has two armories, one at Springfield, Mass., and the other at Rock Island, Ill., equipped for the manufacture of United States service rifles. These plants, when working one full eight-hour shift daily, turn out about 300 rifles per day each, or a total of about 180,000 a year. To equip an army of one million men with one rifle each would require nearly six years of ordinary activity. Even if we now have one million rifles available, the productive capacity must be greatly increased, as it is necessary to provide more than one rifle for each soldier. The experience of the nations now at war is that a modern rifle has to be replaced in less than three months of active use.

This brings us to a consideration of the assistance that can be rendered by private plants. They can be made to turn out supplies quickly if properly tooled and organized, but they will be very slow in producing rifles, for example, unless provided with tools, gages, fixtures and detailed instructions. The manufacture of sets of these tools and fixtures is in itself a great undertaking and should receive the first attention of the munitions board recently appointed.

Generals and soldiers are helpless without engineers, mechanics and toolmakers. Fortunately, we have the best in the world. America is the home of mechanical ability and highly specialized manufacture. The interchangeable system has reached its highest development here, and its advantages are most marked when large quantities of mechanical products are required. The machine shop with its complement of machine tools and equipment and corps of skilled mechanics and toolmakers is the basis of industry. On the machine shop depends all manufacturing enterprise, whether it be devoted to peace or war. American mechanics are renowned for their skill, ingenuity and productive capacity. They are intelligent, and the technical press, by spreading mechanical information and facilitating the exchange of ideas, has played no small part in promoting the development of mechanical ability. The spread of mechanical knowledge must be accelerated in these troubled times. Censorship, if we must have it, should not be so stupidly directed as to interfere with the assistance that can be rendered in making the nation's industry most efficient.

The articles on the manufacture of military rifles that appeared in MACHINERY a year ago gave the first published analysis of the operations on a firearm accompanied by a description of the means and methods to be employed. This article is a sample of the kind of data that should be compiled by government experts for every kind of material required in large quantities. The manufacturing plant as ordinarily organized, having mechanics, toolmakers and other skilled workmen, should be able, with the aid of detailed specifications and the required equipment of tools, to reorganize and begin the manufacture of parts that will pass inspection in a few days. It is claimed that some German plants making products like ball bearings were changed over in twenty-four hours to the manufacture of fuses. This lightning change was made possible by the fact that all preparations had been made beforehand, the tools and equipment were ready, the plans and specifications were on file, and the department heads had been told just what should be done when the war order was received.

The mass of information and data published in the last three years on the manufacture of shrapnel, high-explosive shells, fuses, rifles and other munitions should be of even greater value now than heretofore. This brings us again to a consideration of what has been said in regard to industrial strength and the importance of spreading knowledge of mechanical practice. The many practical articles published during the past twenty years have promoted higher mechanical efficiency and have contributed in no small way to national strength. The man who by reason of intelligence, experience and skill is able to turn out a well finished piece in half the time required by another is twice as strong industrially. The mechanic may be serving the nation more effectively at his daily task than as a soldier in the field.

Technically trained engineers who would serve the country best should carefully compare their relative effectiveness in the army and in industry. Unless a young engineer can be sure that his ability will be utilized in army or navy service, he should by all means be employed in industry. It is to be hoped that our military authorities will not commit the blunder of Great Britain in sending skilled men into the trenches, but will recognize the importance of segregating those who by experience, education and skill are able to direct and produce in industrial employment; they should be regarded as industrial soldiers "doing their bit" most effectively at the forge or lathe.

Automobile manufacturers, who have made America the greatest producer of motor cars in the world, are prepared to take an active part in this national emergency. Means of transportation will be at a premium, and the maker of motor cars will be doing his part if he continues to turn out dependable means of transport. The manufacturers of internal combustion engines of specialized designs will produce aeroplane engines. The aeroplane is the eye of the modern army. Observations made by aviators are absolutely necessary for directing the fire of big guns. Without aeroplanes the army is blind and its efforts are largely futile. The United States may require fleets of aeroplanes which, thanks to our industrial development, can be rapidly and efficiently constructed in plants that have been devoted to the manufacture of motor cars and internal combustion engines. Examples might be multiplied to show the effective part that will be played by the manufacturing industries in war time.

It is the duty of every mechanic, as well as of every manufacturer, to direct his energy and skill to produce that which is required. It is no time for shirking, strikes or interferences with that which is virtually necessary for national security. All men who love liberty and justice should join in this great world battle for democracy—a battle against autocracy which, if successful, will make future wars unnecessary, and in fact improbable. F. E. R.

* * *

INSPECTING FORGINGS FOR HIGH-EXPLOSIVE SHELLS

BY F. E. MERRIAM [1]

The forgings for Russian 3-inch high-explosive shells are rather difficult of manufacture on account of their length and the comparatively small inside diameter of the pierced hole. They therefore require a careful inspection in order that the defective pieces may be found before they pass to the machining operations. The severity of this inspection depends, to a considerable degree, on whether the forging manufacturer or an independent concern is to do the finishing. If the forging manufacturer also does the machining, it will be desirable for him to attempt to finish forgings that an independent concern cannot afford to touch except under special arrangements. The inspection methods described here are those used in a shop in the Middle West, where an independent concern was doing the finishing.

From Fig. 1, it is evident that the punches, or plungers, are long and slender, especially as they must allow sufficient length for a stripper, and therefore are likely to bend and produce eccentric forgings. Since eccentricity is the most common defect, the first inspection has as its object the elimination of all such forgings, the same as in rough-turning. The most common method of turning is to revolve the forgings as true as possible with the axis of the pierced hole, so that the eccentric portion will be removed in the rough-turning operation. Fig. 2 shows the eccentricity testing device, which is simply an expanding mandrel with fingers, or points, set to as small a diameter as is feasible, allowing the forgings to be cleaned up all over. The gage shown in Fig. 3 is sometimes used for determining the eccentricity, and works on the principle that if the inside diameter is correct, and the wall thickness not less than minimum, the shell will machine properly, as far as turning is concerned. As indicated, the measurement is taken as close to the bottom of the forging as the fillet will allow. This gage, however, considers only one cause of eccentricity, namely, improper relation between the axis of the pierced hole and the outside; but the trouble may be due to the forging not being straight. As shown in Fig. 4, there may be a sufficient bend in the forging between the gaging point and the closed end, which this gage cannot detect, to cause failure in the turning operation. This defect is so common that the wall gage is unsafe except when used in conjunction with a straightedge. Another inherent defect of the wall gage is that, by itself, it gives no consideration whatever to the inside diameter. Although a forging may have sufficient wall thickness, because the inside diameter is near the minimum, it cannot be machined if centered true with the axis. To eliminate this difficulty, it is necessary to use a gage of the minimum allowable inside dimensions; Fig. 5 illustrates this condition. On account of these inherent defects, this method of determining eccentricity is no longer used in the shop mentioned, the mandrel being used instead.

The next step in the inspection is an examination of the bottom inside for scale. This is done by setting the forgings open end up and examining them with a properly shaded electric light. Several defects are sometimes found at this time; most of them are due to improper scaling of the billet previous to the piercing operation, or to the introduction of coal dust or some other foreign matter to facilitate the withdrawal of the punches. This foreign matter usually takes the form of a scale-like substance and varies from a few thousandths to a quarter inch in thickness. This scale, of course, prevents the proper gaging of the shell by giving the gages locating from the bottom the wrong position in the forging. For example, all the inside-diameter gages locate from this point, and since the forging is tapered, the presence of undue scale may make it appear to be too large inside and cause it to be rejected. This condition may also cause the wall gage to reject pieces in the same way. But the most serious effect is upon the machining operations, for the scale is very destructive to the tools. Furthermore, the scale may be the cause of failure to finish the bottom inside, especially when the outside of the base is finished previous to the boring operation, because the point of cut-off is then determined from the inside, and when a considerable quantity of scale is present so much stock will be removed from the outside that there will not be enough left for finishing the inside and the shell becomes scrap. Where it is the practice to bore previous to facing the closed end, this difficulty is largely eliminated, but the effect upon the boring tools is the same. During this examination, it is necessary to look for scale on the walls as well as for other defects, such as gas pockets.

Following this inspection comes the measurement of the inside at three points, namely, 0.68 inch from the bottom, half way between the top and bottom, and at the top, both maximum and minimum diameters. The gages for this purpose, shown in Fig. 6, are simply plain diameter gages. It might seem that the gages for measuring half way between the top and bottom might safely be eliminated, but experience shows that to do so would result many times in the acceptance of forgings too large at this point. Occasionally a forging has been found that is as much as 3/32 inch too large at this point but correct as to the top and bottom diameters. The same condition also obtains at times at the gaging point near the bottom. The minimum gages are necessary, because a small plunger is sometimes used by mistake, thus making the pierced hole too small and creating trouble by not allowing the forging to slip on the eccentricity gage and the machining fixtures. Sometimes a forging has ridges on the inside, caused by scoring of the plungers; these produce the same effect as a small punch, as far as gaging and machining are concerned.

The measurement for length and bottom thickness comes next, and is one of the most important items of the inspection. The gage for this is shown in Fig. 7, and when used it is necessary to watch for a suitable bottom thickness and length over-all. Aside from matters of dimension, it is necessary to see that the bottom is of regular form, that the projection for the center is sufficiently long, and that there is not excessive scale or pitting on the outside. Defects due to scale can often be corrected by scaling, and sometimes by chipping, sufficiently to allow the eccentricity test to be made at that point.

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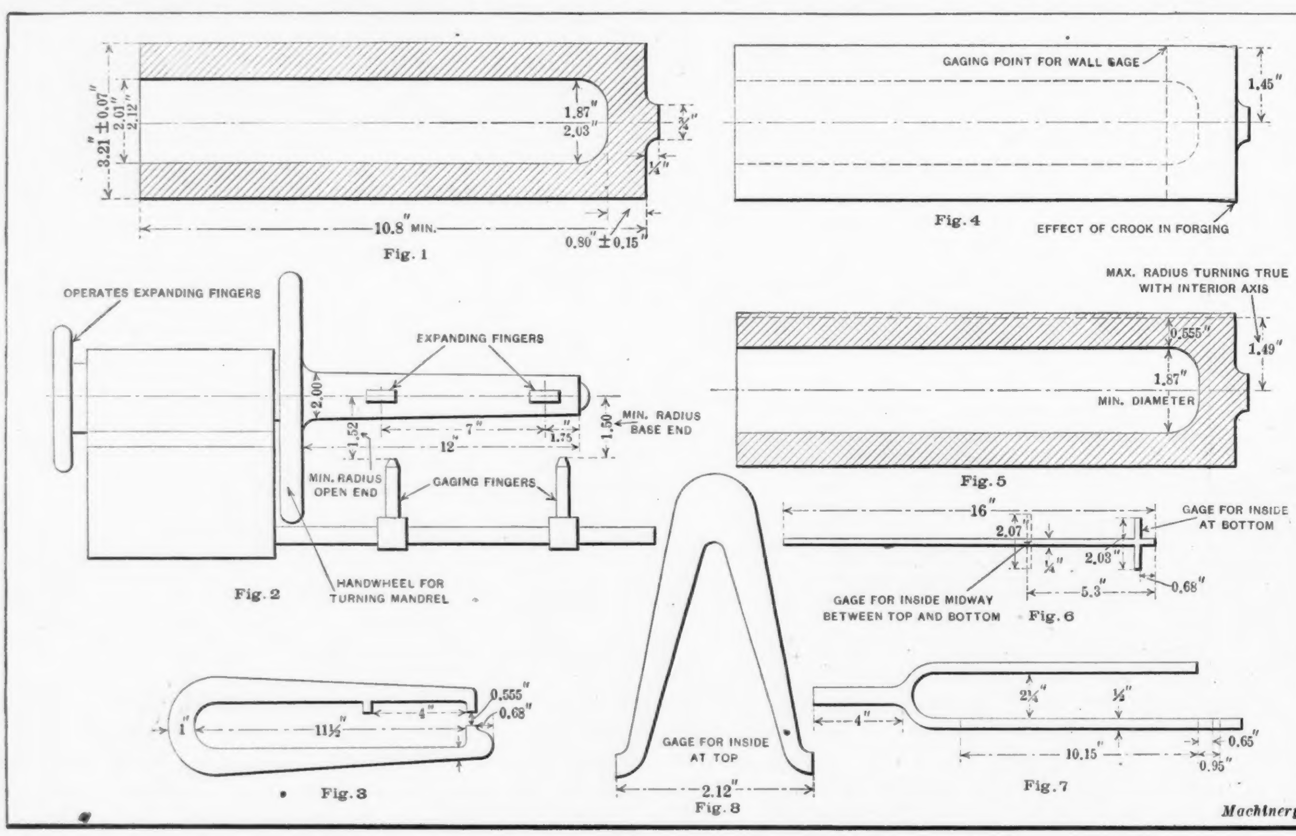
No separate test is necessary, of course, for the wall thickness at the open end, since the eccentricity and the measurement of the inside diameter at this point, with the gage shown in Fig. 8, determine if the forging is satisfactory in this particular. A number of the other tests, such as for the length and bottom thickness, could be made at the same time as the eccentricity test, but it has been found more desirable to handle the work as outlined, since expanding mandrels are expensive and for these tests much slower than the simpler form of gage.

The surface inspection for seams, excessive scale, pits, etc., that is made at the same time as the gaging is an important part of the inspection, because a seam that is not discovered until the shell is finished will cause rejection with loss to all concerned. The examination for excessive scale is also equally important, because it often conceals pits, which may not turn out in the finishing and thus be the cause of final rejection. The only way to discover such defects is by a visual inspection, it usually being found that a porous open scale covers pits. Seams are sometimes so fine, of course, as to be impossible of discovery until the shell is finished, but most of them can be detected in the forge shop if a careful search is carried out.

The inspection of forgings is not as simple as many appear to believe, for there are many new things constantly arising that call for a knowledge of more than forge work and drawings. The eccentricity test is undoubtedly the most important, since failure to turn has been the cause of more rejections than any other one thing. The rejection of a forging on this test, however, does not necessarily mean that it cannot be machined, but it does indicate that it cannot be machined unless unusual precautions are taken. If the forging manufacturer is machining his own forgings, he will find it profitable to use special methods on forgings rejected on this test, since he can thereby save many of them. Oftentimes this work will call for centering eccentrically with the inside or rough-turning to nearly the finished size, but this is always more desirable than scrapping the forging. If there are but a few forgings to be machined, the inspection methods are not of great importance, but when the quantity runs into the hundreds of thousands, it becomes quite as important as any of the other operations and very necessary if production costs are to be kept low.



Figs. 1 to 8. Forging for High-explosive Shell and Gages testing Dimensions

CAUTION TO EMPLOYES OF FOREIGN BIRTH

In view of complications that might otherwise develop with workmen of foreign birth, J. H. Williams & Co., manufacturers of drop-forgings, having factories in Brooklyn and Buffalo, have issued the following cautionary statement to their employes, which is to be commended for fairness and straightforwardness. If other manufacturers generally deal with their employes in the same frank and democratic spirit, national feelings and prejudices engendered by the war will be largely submerged in manufacturing plants.

In the present crisis in our relations with the German government it is the purpose of this company to treat all of its employes alike, regardless of nationality of birth, or descent. The company expects from all in its employ the same loyalty that has been proved so often in the past, and takes it for granted that this loyalty will be extended in even greater measure to the policies of the United States government.

We cannot do otherwise than endorse the suggestion of the President that we all, in our various relations with each other, allow no accident of heredity to influence our feelings at this time toward those who are loyal American citizens.

J. H. Williams & Co.

J. H. Williams, President

* * *

NEW ENGINEERING SOCIETY ORGANIZATION

A new engineering society was organized at a convention held in El Paso, Texas, March 8-10, with more than one hundred charter members, which will be known as the Southwestern Society of Engineers. Membership is open to civil, mechanical, mining, electrical, or chemical engineers, architects and other persons belonging to a technical profession, who are not less than twenty-seven years of age, and who have been in active practice of their profession for at least six years. Provision is also made for associate, honorary, and affiliated members. The president is Dean A. F. Barnes, School of Engineering, New Mexico College of Agriculture and Mechanic Arts, College Station, New Mexico; secretary, Forrest E. Baker, El Paso, Texas; vice-presidents, Dean G. M. Butler, College of Mines and Engineering, University of Arizona, Tucson, Ariz., and Dean S. H. Worrell, Texas College of Mines, El Paso, Texas.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

HEALD ROTARY SURFACE GRINDER

Simplicity of design and adoption of a unit principle of construction are the two outstanding features of this machine. Five units comprise the entire mechanism, and any of these can be easily removed if necessary. Provision is made for grinding concave and convex surfaces in addition to flat surfaces, making the machine suitable for handling a wide range of work.

A new size of rotary surface grinding machine has recently been brought out by the Heald Machine Co., 20 New Bond St., Worcester, Mass., for grinding rings, washers, thrust collars and similar parts that have flat surfaces to be finished by grinding and that can be held on a magnetic chuck. The most noticeable features of this 12-inch rotary surface grinder are the simplicity and compactness of its design and the fact that the machine is built on the unit principle. The entire mechanism consists of five units, *viz.*, the driving shaft bracket, idler pulley bracket, speed and feed box, wheel-spindle ram, and work-spindle knee, all of which are self-contained units which may be easily attached to or removed from the machine. In this connection, it may be mentioned that the unit type of construction lends itself well to the application of either belt or motor drive, it being merely

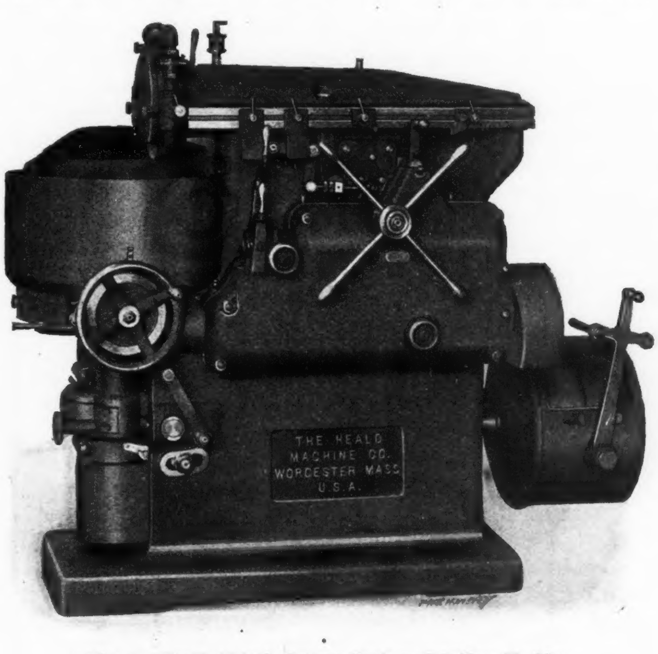


Fig. 1. Heald 12-inch Rotary Surface Grinding Machine

necessary to assemble a pulley drive bracket or a motor drive bracket on the machine, according to the requirements of different cases.

In order to explain the features of design of this grinder, there is probably no better way than to follow the transmission of power from the main driving pulley to different members of the machine. The main driving shaft bracket is shown in Fig. 3, from which it will be seen that the tight and loose pulleys *A* and *B* are located at the left-hand end. Loose pulley *B* is of smaller diameter than tight pulley *A*, so that the belt tension is relaxed while the belt is not driving the machine. Power for driving the wheel-spindle is taken from pulley *C* by a belt, the tension of which is kept uniform by a special form of idler pulley illustrated in detail in Fig. 4. Reference to this illustration will show that the pulley is supported by a swinging arm which holds it in contact with the belt through the action of a torsion spring. The strength of this spring is adjusted to maintain exactly the required belt tension, and allows for any unusual demand upon the

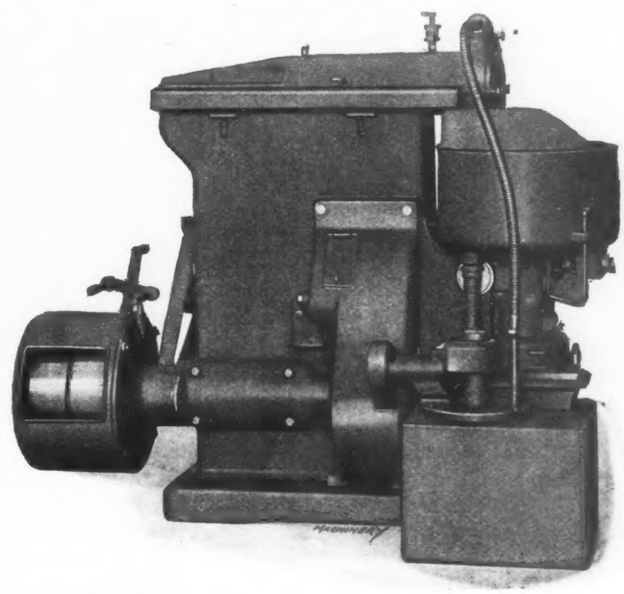


Fig. 2. Opposite Side of Heald Rotary Surface Grinder shown in Fig. 1

drive. It will be seen that the idler pulley is supported on ball bearings.

At the extreme right-hand end of the main driving shaft is a small pulley *D*, Fig. 3, which transmits power to the pump; and about midway along the shaft there is a third pulley *E*, from which power is transmitted to the feed and speed box located at the opposite side of the machine. Two views of the speed and feed box are shown in Fig. 5, and in this illustration it will be noticed that connection is made with pulley *E* on the main driving shaft at the back of the machine by a belt running over pulley *F*. The most important feature of design of the speed and feed box is that changes of both speed and feed are secured by two cones of gears which mesh with a common cone of gears keyed to shaft *G*. Any of the available rates of speed or feed is obtained by clutching the proper gear to the speed shaft or feed shaft, as the case may be, by means of diving keys *H* which are actuated by knobs *I* and *J* at the front of the speed-box. When so desired, the drives of both the speed and feed gears may be disconnected by throwing out keys *H*.

From the speed and feed box power for driving the work-spindle is transmitted by bevel pinion *L* through a suitable ar-

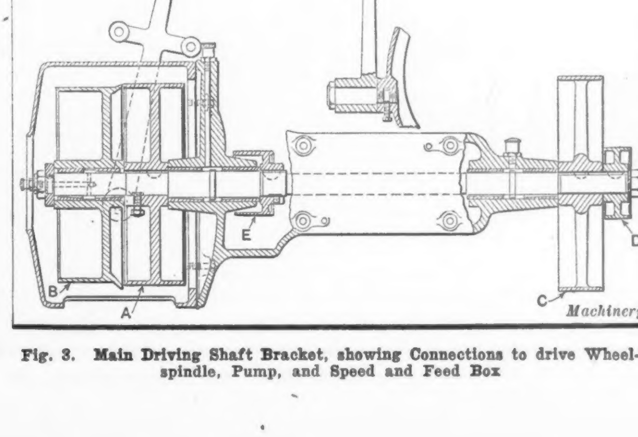


Fig. 3. Main Driving Shaft Bracket, showing Connections to drive Wheel-spindle, Pump, and Speed and Feed Box

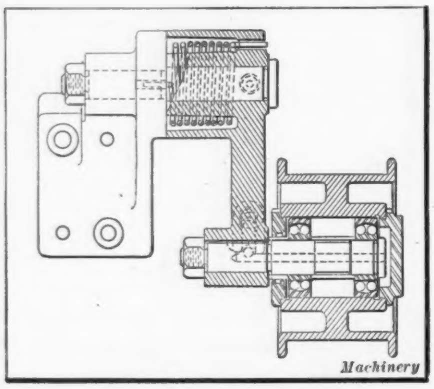


Fig. 4. Idler Pulley for maintaining Constant Tension on Wheel-spindle Driving Belt

rangement of gearing and shafts to a pinion that meshes with a spur gear *M*, Fig. 7, keyed to the vertical work-spindle. It will be seen that the lower end of the work-spindle is held by a radial ball bearing and there is a taper bearing at the top which keeps the spindle concentric and compensates for wear. Vertical feed of the work-spindle is automatically controlled by dogs on the wheel ram, which actuate a ratchet and pawl shown at *N*. These stops may be set to obtain any desired rate of feed, and an adjustable shield on the ratchet provides for disengaging the feed at any desired point. From the ratchet power is transmitted through shafts and gearing to pinion *O* that meshes with a combination gear and nut carried on the feed-screw. It will be evident from the illustration that rotation of the nut around the feed-screw provides for feeding the work up to the grinding wheel. A ball bearing under the nut supports the downward thrust of the work-spindle.

Referring again to Fig. 5, which shows the arrangement of gearing in the speed and feed box, we are now in a position to take up the manner in which power is transmitted to provide reciprocating motion for the wheel-spindle ram. The cone of gears which provides the changes in feed is carried on shaft *P*, which supports two bevel pinions between which is clutch *Q*. On the wheel-spindle ram there are adjustable stops that engage lever *R* at each end of the stroke, which results in throwing clutch *Q* into engagement with the forward and reverse bevel pinions on shaft *P*, thus providing the reciprocating motion of the wheel ram. These bevel pinions both mesh with a bevel gear carried on a cross-shaft, from which motion is transmitted through a vertical shaft to worm-wheel *S*, which meshes with a fixed worm on the wheel ram and results in forward or reverse traverse of the ram, according to the bevel pinion on shaft *P* that is engaged by the clutch *Q*.

Provision is made for grinding "convex" or "concave" tapers by setting the work-spindle bracket either to the right or left of the neutral position in which flat work is ground. Referring to Fig. 7, it will be seen that a scale *T* is provided to

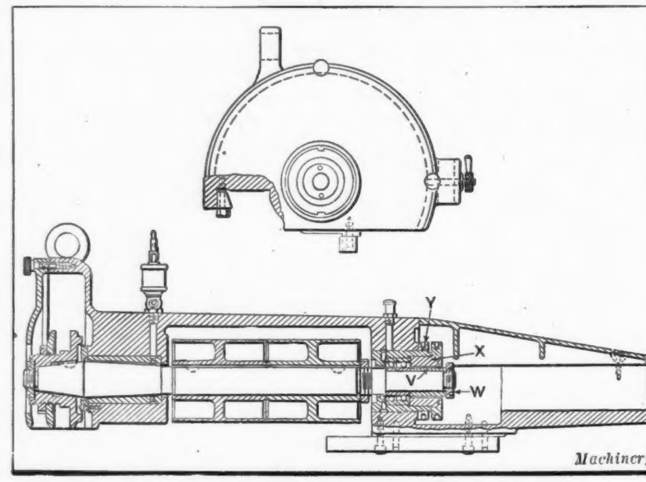


Fig. 6. Sectional View through Wheel-slide, showing Improved Type of Spindle Bearing Construction

facilitate making this setting; and the work-spindle knee is swung about shaft *V*, on which is mounted the driving pinion that transmits power to this section of the machine. In this way, the angular setting may be made without interfering with the transmission power.

From Figs. 1 and 2 it will be seen that all working parts are covered by guards which provide for the safety of the operator and also protect delicate parts of the mechanism from damage. In conformity with the best practice of machine design, the control of all parts of the mechanism is centralized so that the operator has complete control of all movements without being required to leave his position at the front of the machine. Another feature that adds to the efficiency of operation is the fact that the handles of all handwheels are made separate from

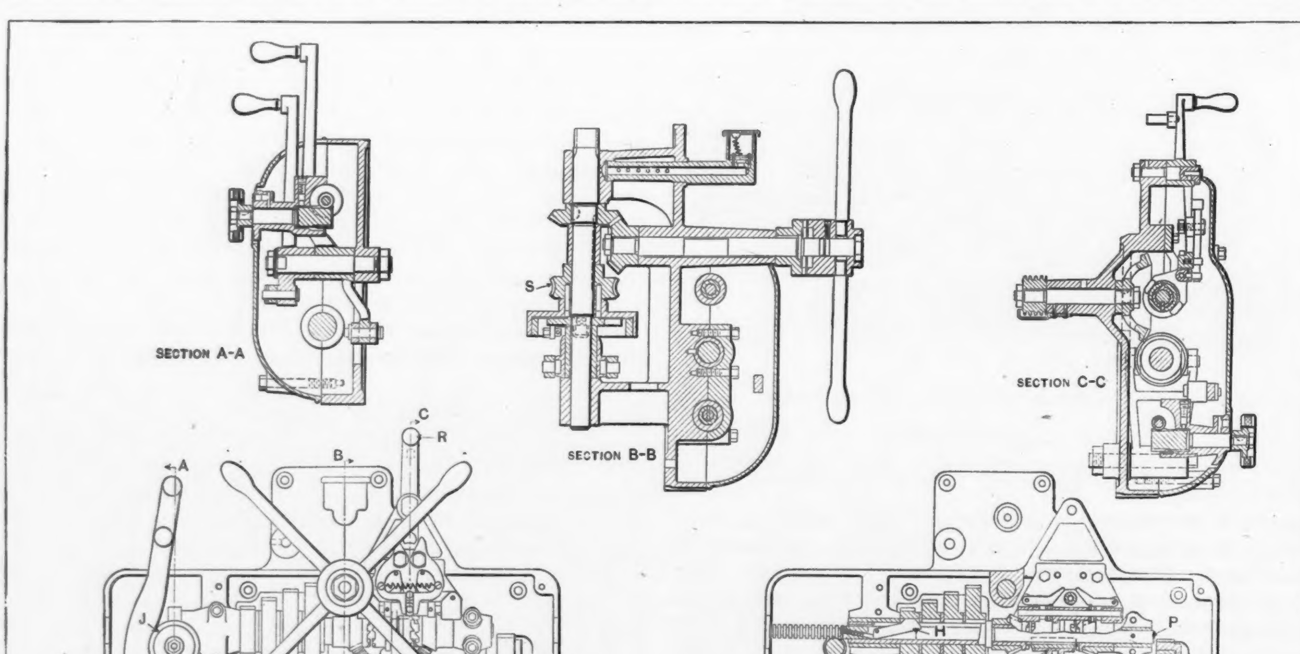


Fig. 5. Arrangement of Gearing in Speed and Feed Box, and Transmission to Wheel-spindle Slide

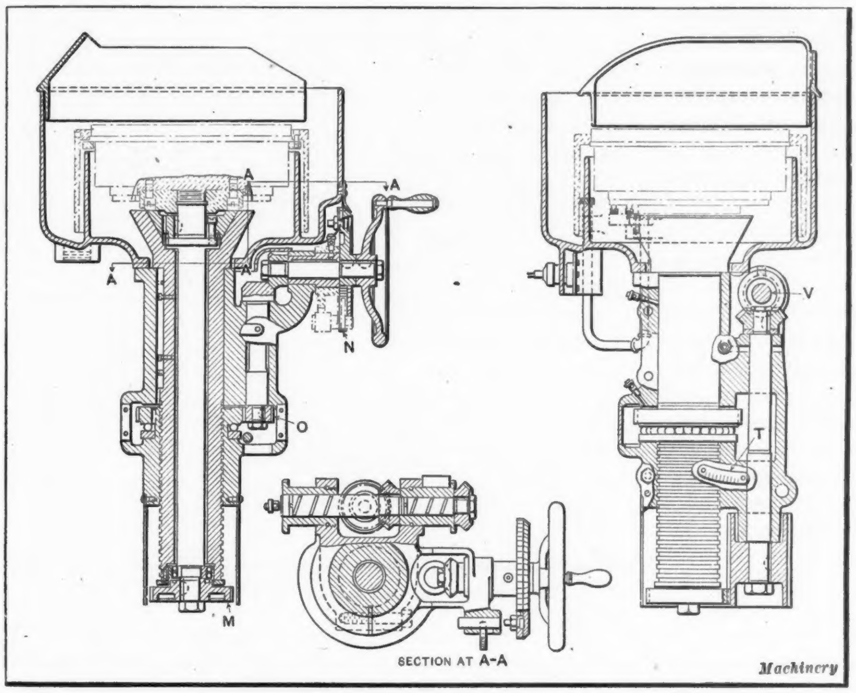


Fig. 7. Sectional View of Work-spindle Knee, showing Feed Mechanism and Means for grinding Tapered Work

the studs which support them, so that the handle remains stationary in the operator's hand while the wheel is turned. This may appear to be an unimportant matter, but those who have had experience will realize that the constant turning of a handle in the hand is a source of fatigue, and results in reducing production.

Attention is called to the design of the wheel-spindle illustrated in Fig. 6. It will be seen that a plain bearing is used to support the front end of the spindle, but this bearing is tapered and made in a single piece, as the experience of the Heald Machine Co. has shown that better results are obtained in this way than by employing a split bearing. At the rear end of the spindle there is a double ball bearing, the inner races of which are clamped to the spindle by means of sleeve *V* and binding nut *W* that force the races up against a shoulder turned on the end of the spindle. Similarly, nut *X* adjusts the position of the outer races in the proper relation to the inner races and balls. When it becomes necessary to compensate for wear in the taper front-spindle bearing, such adjustment is made by tightening nut *Y*, which draws the entire spindle back into the taper bearing. Running tests made with this bearing in the shops of the Heald Machine Co. are said to have shown exceptionally satisfactory results, and the importance of efficient operation at this point will be conceded by all experienced grinding machine operators, as the high speed at which grinder spindles are run makes the design of the spindle and spindle bearings a matter of importance.

The principal dimensions are as follows: diameter of magnetic chuck, 12 inches (8- or 10-inch chucks can also be used if desired); size of grinding wheel, 12 inches diameter, 1 inch face, 3½ inches hole; greatest distance from top of chuck to center of wheel, 9½ inches; vertical adjustment of chuck, 5 inches; largest swing inside water pan, 15 inches.

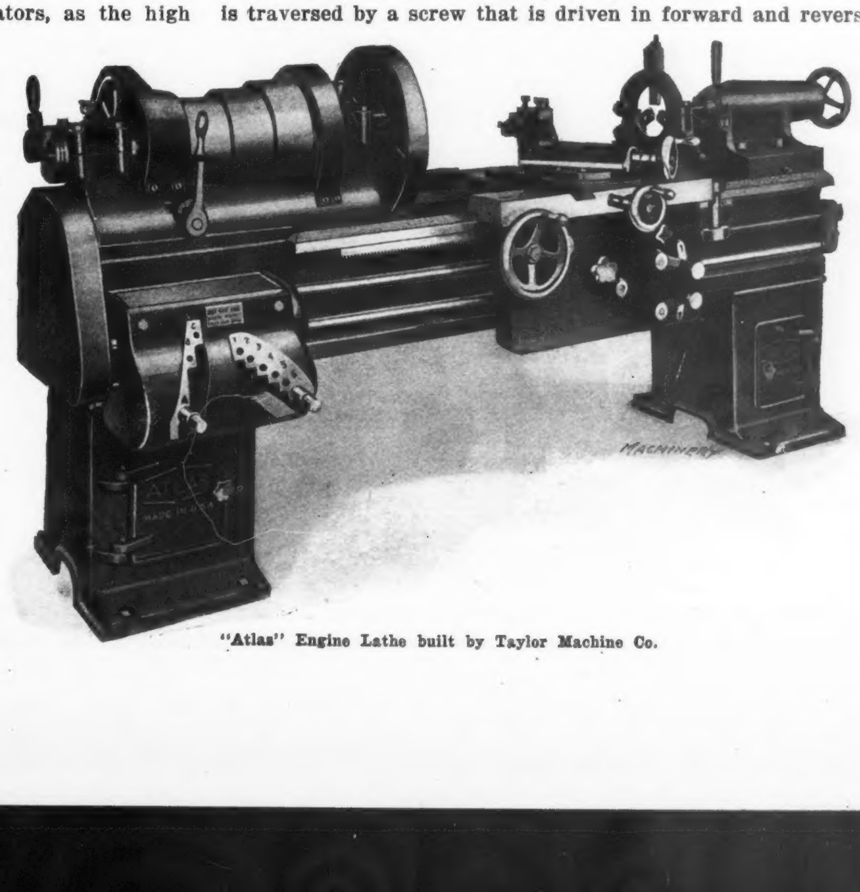
"ATLAS" ENGINE LATHE

The Taylor Machine Co., 7804 Carnegie Ave., Cleveland, Ohio, is now building a 20-inch "Atlas" engine lathe equipped with a double back-geared drive, quick-change gears, and other features which will be apparent by reference to the accompanying illustration. Machines of this type are built with eight-, ten- and twelve-foot beds, furnished with heavy double-wall cross girths spaced two feet apart, which provide a rigid construction capable of resisting severe stresses. There are two ways on the bed, and a 20 per cent steel mixture is used, which provides a harder metal than that in the carriage bearings, so that any wear which takes place will be confined to the carriage, where adjustment can be made. The high-carbon steel feed rack is pinned and bolted to the bed.

The compound rest has its swivel made completely circular and graduated in degrees, the rest being clamped to the cross-slide by means of heavy bolts. Full-length tapered gibs with end screw adjustment are provided on both cross and compound slides, and are placed on the side where they will not receive the thrust of the tool. The headstock is of the closed type and is designed to meet the requirements of heavy work. The spindle is turned from 50-point carbon steel and is carried by phosphor-bronze bearings. The tailstock spindle is clamped by means of a double binder which is so constructed as to clamp the spindle in any position without affecting its alignment. Sight-feed oil cups are provided on the front spindle bearing and all other bearings are furnished with Brown & Sharpe oil plugs. There is a thrust bearing on the spindle which consists of bronze and hardened steel collars. A one-piece apron construction is employed in which all bearings are cast integral; and all gears are furnished with bearings at both ends. The lead-screw is turned from 40-point carbon steel and is 1½ inch in diameter with a 4-pitch thread.

"HY-GRADE" CYLINDER GRINDER

To meet the requirements of garages, repair shops, etc., which are called upon to handle cylinder grinding, the Hy-Grade Machine Co., 5606 Curtis Ave., Cleveland, Ohio, is now building a cylinder grinding machine. The upright frame and lower surface table are cast integral; and the vertical ways and bottom surface are carefully machined and scraped perfectly square to insure accurate alignment. The cylinder to be ground is mounted on a plate which may be adjusted to bring the different bores into the grinding position, this plate being carried on ways that extend the full length of the machine. The spindle is carried in a movable head and may be eccentrically adjusted to travel around the bore of the cylinder while rotating on its own axis. This spindle is driven by a belt extending back through the ways upon which the head is traversed by a screw that is driven in forward and reverse



"Atlas" Engine Lathe built by Taylor Machine Co.

directions by bevel gears. Up and down feed is controlled by a rod with adjustable stops that govern the clutch between the two bevel gears. Revolution of the spindle is controlled by a clutch on a splined shaft driven by spur gears. The fine eccentric feed is operated by a worm or screw furnished with a graduated dial.

All operating levers are located at the front of the machine where they are convenient for the operator. Counterweights relieve the machine of all strain and tendency toward excessive wear. All sizes of automobile cylinders may be ground, and it is claimed that the machine is capable of attaining a high rate of production and doing accurate work. The spindle head is equipped with adjustable bronze bearings, and the spindle is carried by double-row ball bearings and adjustable bronze bearings which are furnished with leak-proof oil retainers. The principal dimensions of the machine are as follows: height, 6 feet; total travel of spindle head, 22 inches; length of grinding spindle, 16 inches; size of movable plate that supports the work, 16 by 22 inches by 2½ inches thick; working space under machine, 18 by 22 inches; and floor space occupied, 28 by 32 inches.

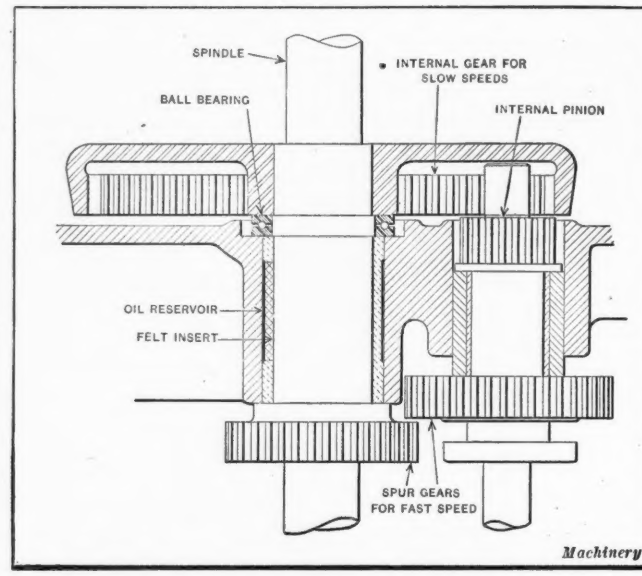


Fig. 2. Selective Internal and External Geared Drive to Spindle

AMERICAN RADIAL DRILLING MACHINE

In working out the design of a six-foot radial drilling machine which has recently been placed on the market by the American Tool Works Co., Cincinnati, Ohio, provision has been made for the performance of boring operations in addition to drilling and tapping, and on this account the machine has been termed a "triple-purpose" radial drilling machine. This result is accomplished by providing a quadruple geared head, affording four distinct speeds, which, in turn, are divided into two separate ranges of two speeds each—one for heavy tapping and boring, and the other for high-speed drilling and light tapping. The boring and tapping range, in conjunction with the eight gear-box speeds, comprise sixteen speeds ranging from 15 to 81 revolutions per minute, which are obtained through an internal gear drive on the spindle, while the high-speed drilling range consists of sixteen speeds from 94 to 500 revolutions per minute, secured through an external gear. These internal and external gear drives are non-interfering, and the thirty-two spindle speeds are in geometrical progression. A clear idea of the arrangement of the external and internal geared drive to the spindle will be gathered by reference to Fig. 2. At first thought it would seem that in supplying such a wide spindle speed range as 15 to 500 revolutions per minute, excessive gear velocities would be encountered, and this would be unavoidable were it not for the use of the double-spindle gear drive; but with this drive no gear runs faster than 1000 feet per minute, which is quite conservative. The head mechanism is fully enclosed inside of one large casting or housing, which not only prevents all possibility of accident from exposed running parts, but also presents a neat and finished appearance.

One important feature of this machine is found in the tapping mechanism, which is completely enclosed and runs in oil. Particular attention is called to the fact that with the added facilities furnished by this machine, there has been no complication of the mechanism or method of operation. For instance, thirty-two spindle speeds are obtained with only fifteen gears in the speed-changing mechanism. As to the convenience of operation, a study of the illustrations will be sufficient to give an idea of the way in which this has been provided for in the arrangement of all operating members. The different levers on the head are located so the operator can reach them easily, and two head-moving handwheels are provided, one on each side, so that either is available for instant use. Two levers are furnished for raising or lowering the spindle, and only one dial is used for the eight feeds. A conical roller bearing interposed between the column and sleeve make the arm easy to swing, this result being further facilitated by a ball bearing at the top which takes the radial thrust of the sleeve.

Thorough lubrication is a point of exceptional importance in radial drilling machines because of the number of vertical bearings and high velocity of the shafts. On this account oil ducts from the bearings are brought to centralized locations on the head and cap, into which oil may be introduced. This method insures an oil supply for every pipe and bearing. To further provide for efficient lubrication, a special bearing design has been worked out, this being of the type shown in Fig. 3. Oil is led into the annular chamber formed in the bronze bushing, which contains a large supply of lubricant, which, in turn, is fed to the bearing by means of a strip of felt inserted in a slot cut lengthwise in the bushing. This construction insures a continuous and uniform supply of clean oil for the bearing, and prevents waste from oil flooding and running out of the bearing before performing its function. To avoid possible accidents through falling of the counter-

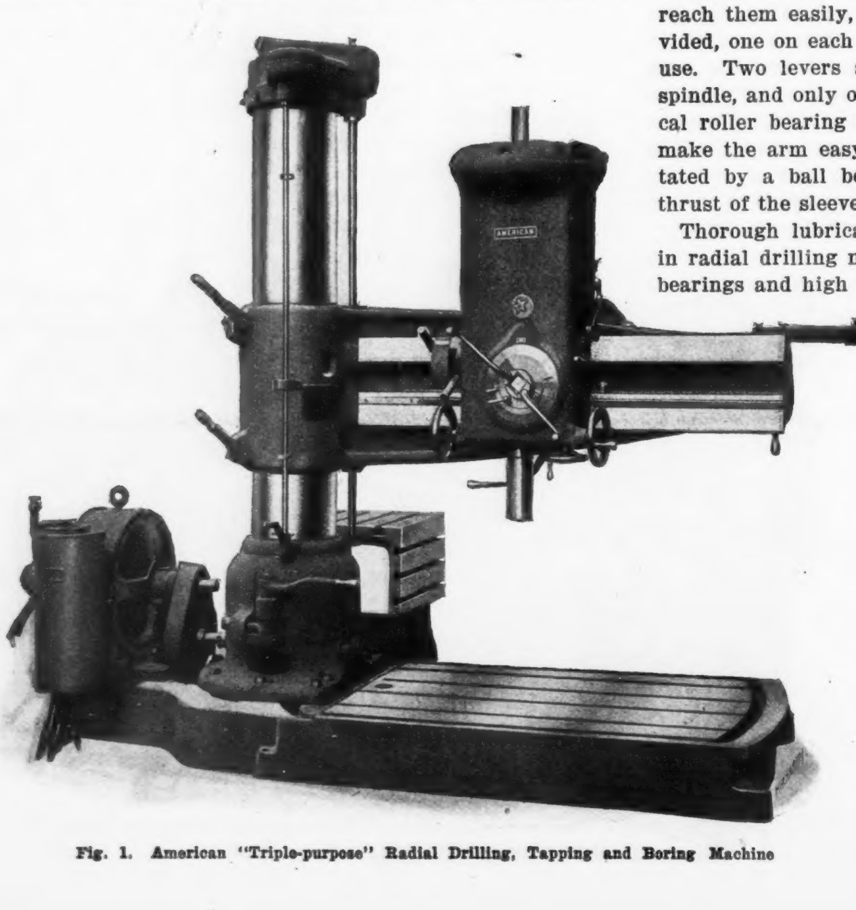


Fig. 1. American "Triple-purpose" Radial Drilling, Tapping and Boring Machine

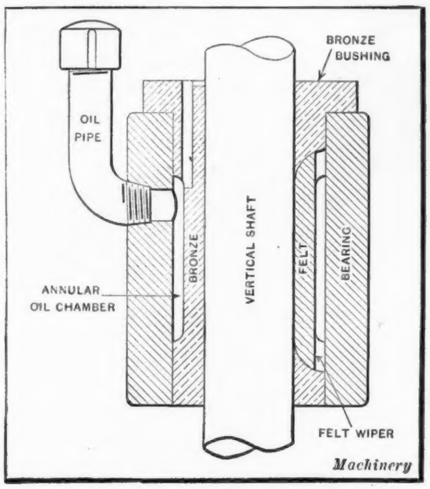


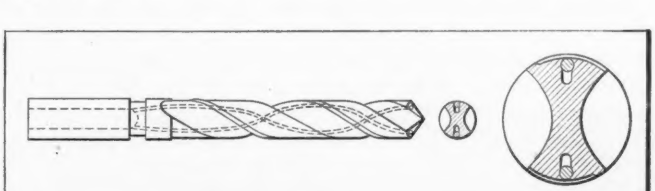
Fig. 3. Special Type of Bearing with Provision for Constant Lubrication

shaft, the weight on this machine is completely enclosed and provided with a safety stop which operates automatically in event of the supporting chain breaking; in this way the possibility of accident has been eliminated.

Eight changes of feed are provided, these being in geometrical progression and ranging from 0.005 to 0.040 inch per revolution. The feed mechanism is direct-reading, and only one dial is required for its operation. Thorough protection is provided for the feed mechanism to guard against sudden shocks or excessive strains, this result being obtained by means of a friction that constitutes the connection between the mechanism and the spindle, and acts as a "slipping point." This friction is of an improved expanding band type, and is quickly adjustable for the desired tension. The feed worm-wheel runs in an oil bath, insuring a minimum of wear between the worm-wheel and worm. Eight changes of speed are furnished by a cone and tumbler type gear-box, which has an automatic silent clutch auxiliary drive that keeps the shafts and gears running while speed changes are being made. This is the means of eliminating much of the shock caused by engagement of gears. It is impossible to elevate the arm until the binding levers have been loosened, and the arm cannot be elevated or lowered beyond certain fixed points. Whenever the elevating mechanism is engaged there is ordinarily a noticeable shock caused by meshing of the gears, but this shock is absorbed by the friction mechanism, so that it does no damage. This elevating mechanism is controlled by a lever that is inoperative until raised from its bearings, thereby guarding against breakage through careless handling. An automatic knock-out is also provided for the elevating shaft, which automatically disengages the mechanism at the extreme upward or downward movement of the arm, thus preventing damage from this source.

LINCOLN-WILLIAMS OIL-TUBE DRILL

The Lincoln-Williams Twist Drill Co., Taunton, Mass., has developed a new type of oil-tube drill, which is now ready for the market. Oil-tube drills of the type in which the tubes are soldered in place have often been found unsatisfactory, having given more or less trouble from the tubes working loose, and interfering with efficient drilling. In the Lincoln-Williams type of oil-tube drill, which is illustrated in the diagram presented herewith, the oil-tube is cut into the solid metal and the outer wall of the tube is formed by an inserted piece of drill rod which is dovetailed into place. This rod cannot work loose or come out, and the resulting oil hole formed from the solid metal and closed by the drill rod is in every way equal to that in the usual type of oil-tube drill. The oil-tube channels run back into the shank of the drill, where a connection by cross-holes is made to a central hole that runs out at the end of the shank, thus providing an entrance for cutting lubricant.

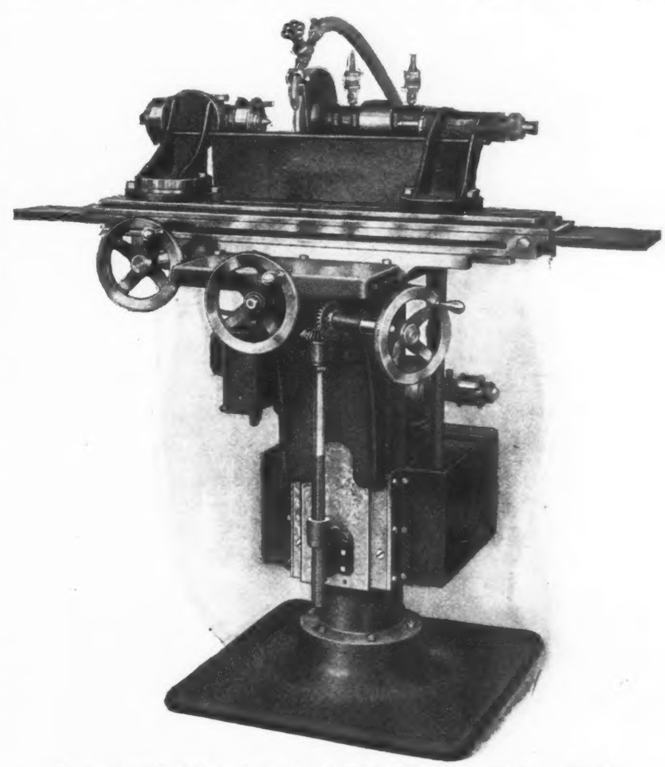


Oil-tube Drill made by Lincoln-Williams Twist Drill Co.

"CONNECTICUT" UNIVERSAL GRINDER

The Middlesex Machine Works, Middletown, Conn., are now building a machine known as the "Connecticut" universal grinder, which is shown in the accompanying illustration. The most important feature of design is the column construction which allows the table to swing completely around on bearings of liberal size, so that this grinder is a full universal machine. The head is fastened to the column, and any position can be obtained without twisting the belt. Another important feature is the ease and rapidity with which the grinder can be changed over from cylindrical wet grinding to surface grinding. This is particularly important in tool-room work or in manufacturing shops where the grinder is used for a variety of work. An internal grinding attachment can also be applied in a few moments to adapt the machine for those operations for which such an attachment is required.

The universal headstock has a No. 10 Brown & Sharpe taper in the removable sleeve, making it possible to use regular milling machine arbors, collets, etc.; and all kinds of cutter grinding can be done without requiring the use of extra fittings. The universal headstock is also provided with a draw-back attachment made to receive special collets that may be used for grinding small cylindrical parts. The spindle is made with a 15-degree taper on each end, and two flange bushings are made to fit on the ends of the spindle. These make it possible to change wheels and maintain their true relation to the work, eliminating the necessity of truing the wheel. A



"Connecticut" Universal Grinder built by Middlesex Machine Works

water supply is available for wet grinding. This machine is adapted for taking very heavy cuts when roughing, and also for taking the lightest cuts where accuracy and a high finish are necessary, the claim being made that the machine operates with uniform efficiency under all conditions.

It will be noted that the table has no overhang, because it is supported for its entire length by the longitudinal slide, which is heavily braced and held in its turn by two generous bearings on the column. With this rigid support for the work, a remarkable degree of accuracy can be obtained. The top platen rests for its full length upon the longitudinal slide upon which it swivels, and is provided with a screw adjustment for aligning the centers accurately. The ends are graduated to facilitate setting for handling tapered work, one end being graduated to read tapers in inches per foot and the other end in degrees. The longitudinal movement is operated by a rack and pinion and the cross movement by a feed-screw furnished with micrometer adjustment.

The principal dimensions of this machine are as follows: diameter of spindle, 1½ inch; length of front bearing, 4½ inches; length of rear bearing, 3¼ inches; longitudinal movement of table, 20 inches; vertical movement of table, 13 inches; transverse movement of table, 8½ inches; capacity for handling work on centers, 24 inches in length by 12 inches in diameter; working surface of table, 5⅞ by 34 inches; maximum distance between spindle and table, 9 inches; height from floor to center of spindle, 45 inches; diameter of column, 7 inches; width of driving belt, 2½ inches; and net weight of machine, including attachments and countershaft, 1200 pounds.

Fig. 1. Progress Spring Tool-holder for Performance of Threading and Forming Operations

"PROGRESS" SPRING TOOL-HOLDER

Most mechanics are familiar with the advantages obtained through the use of the so-called gooseneck or spring-tool that is commonly used for threading and forming operations. It is a matter of general knowledge that such a tool does not dig in and tear the work, which is likely to occur when a straight tool is used for these operations. With the view of overcoming such troubles and also to take advantage of

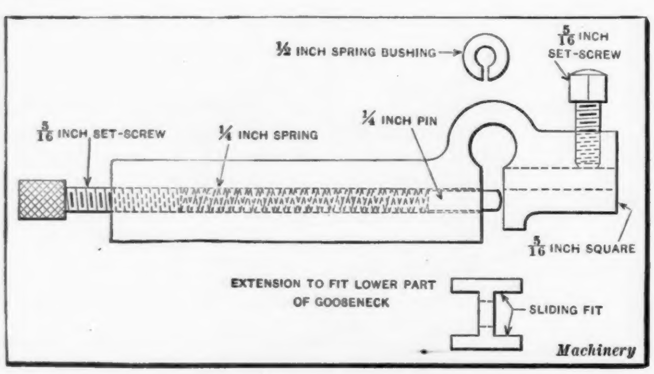


Fig. 2. Arrangement of Spring Bushing, Spring Support for Gooseneck and Sliding Extension to fit into Slot

the economy of a tool-holder, the Progress Mfg. Co., Erie, Pa., is now making the spring tool-holder illustrated and described herewith. Cutters used in this tool-holder can be made of 5/16-inch square or round stock. A spring bushing is placed in the gooseneck to stiffen the tool and afford additional spring when cutting coarse threads or performing heavy forming operations. A spring is placed through the shank of the holder, and this can be tightened by a knurled set-screw; the spring bears against the lower part of the gooseneck and is used when roughing out a thread or performing similar operations, after which the spring is released for finishing the work. Any forming cutter can be used in the tool-holder to advantage.

RUSSELL ROUND ADJUSTABLE DIE

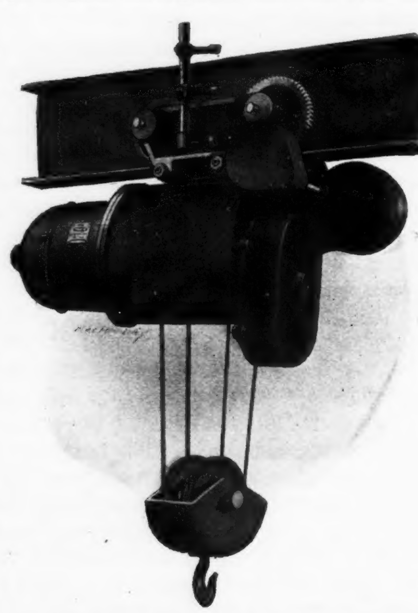
One of the latest products of the Russell Mfg. Co., Greenfield, Mass., is a round adjustable die, which is shown in the accompanying illustration. Dies of this type may be adjusted while in the holders by means of a taper-headed screw which engages a cone-shaped nut at the opposite side of the die. The taper head of the screw bears against a countersunk recess at the front face of the die, while the conical nut bears against a similar recess in the back face. It will be evident that this causes the die to open evenly and avoids the possibility of trouble through a twisting action. These new Russell round adjustable dies will fit any make of holder, as the slot running across the entire edge will engage with the set-screw no matter where the latter may be located.

Russell Round Adjustable Die

"AMERICAN" ELECTRIC HOIST

The "American" electric hoist shown in the accompanying illustration has recently been placed on the market by the Barber-Foster Engineering Co., 605-607 Swetland Bldg., Cleveland, Ohio. These hoists are made in different types, which include a plain trolley hoist built in sizes from ¼ to 2 tons capacity, a geared trolley and hand chain hoist built in capacities from 2 to 10 tons, and a motor-driven trolley hoist for remote control, which is also built in capacities from 2 to 10 tons. Each type of hoist is completely enclosed, making it suitable for outdoor service or where exposed to dust, dirt, acid fumes, etc. All gears are cut from solid heat-treated steel blanks and the shafts are hardened and ground at the bearings. The mechanical brake is of a simple double-friction disk type, and Hyatt roller bearings are used to increase transmission efficiency. The motor and controller are of a standard design especially adapted for heavy-duty hoisting service; and the hoists may be provided for use in connection with either alternating or direct current.

Cast iron is used for the hoist frame, which is cylindrical in form and so constructed that it entirely encloses all the mechanism, including the drum and brakes. By locating the drum centrally within the frame, only a very small opening is required for the rope to pass through, so that not even the drum is exposed. The section of the frame containing the gearing and mechanical brake is separated from the drum by a cast-iron partition and is packed with grease. The drum is made of cast iron and machined with grooves to receive the full amount of rope for a given lift without overlapping. Attention is called to the fact that the drum gear is keyed to the end of the drum and not to the drum shaft. A mechanical load brake automatically stops and holds the load when the motor is stopped, and this brake is not released until the motor starts revolving in the lowering direction.



"American" Electric Hoist built by Barber-Foster Engineering Co.

Through the use of roller bearings and by having the gears run in grease there is little need of lubrication, although the bearings are provided with means for lubricating with oil. The trolley consists of two castings securely connected to lugs on the frame by through bolts which are of ample size. By simply removing these bolts the hoist is detached and each trolley frame with its wheels may then be easily removed from the I-beam. These wheels are single-flanged with tapered treads, and they are equipped with Hyatt roller bearings. An automatic limit stop is provided to prevent over-travel of the block in the hoisting direction due to neglect of the hoist operator. This stop is actuated by direct contact of the block.

MOCCASIN SELF-OILING BUSHINGS

For use as a bearing for loose pulleys and for similar applications where it is desirable to have the combination of an efficient bearing metal and an automatic lubricating system, the Moccasin Bushing Co., Chattanooga, Tenn., has placed on the market a line of self-oiling bushings which form the subject of the following description. Probably the best idea of how these bushings are used will be gathered from Fig. 2, which shows a Moccasin bushing in a loose pulley that is provided with an oil reservoir in the hub. The principle on which lubrication of this bushing is effected is the same as that by which oil is drawn up through a lamp wick, *i. e.*, capillary attraction. These bushings may be used in any machine member furnished with an oil cavity from which lubricant may be drawn by the capillary feeders in the bushing, which carry oil to the bearing. These capillary feeders pass transversely through the bushing to the bearing surface, where the oil is deposited in a continuous film. The feeders are especially prepared so that they cannot glaze or clog, and they have great power to hold oil and give it off as required. A special metal mixture is employed in making the bushings, which has ample strength without too much hardness. A further claim made for these bushings is that they obviate waste of oil, which is an important factor in many places. This saving, in addition to increased transmission efficiency, makes these bushings the means of effecting a considerable saving.

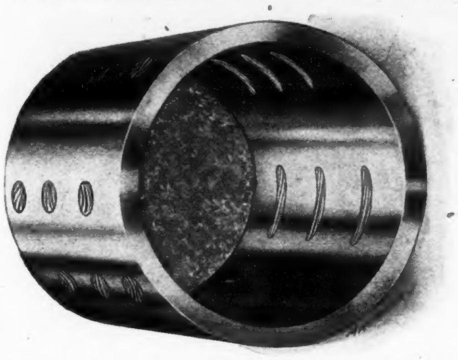


Fig. 1. Moccasin Self-oiling Bronze Bushing

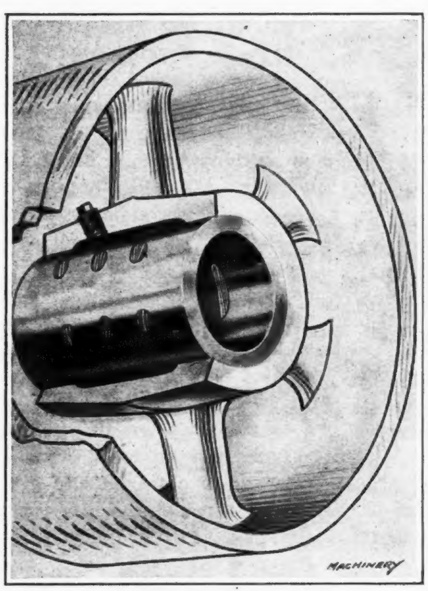
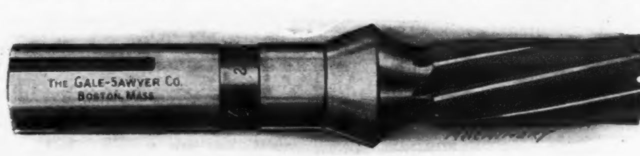


Fig. 2. Application of Moccasin Bushing in Loose Pulley

GALE-SAWYER ELECTRICALLY WELDED TOOLS

The accompanying illustration shows an end-mill made by the Gale-Sawyer Co., 33-37 Wormwood St., Boston, Mass. This tool has been electrically welded just above the cutting point, and by a series of special heat-treatments before and after welding, the steel is so united that it is claimed to be capable of withstanding a greater strain at the welded joint than in any other portion of the tool. After fitting the welding surfaces together, the steel is heat-treated in preparation for welding, the welding being done on a butt-welding machine which applies different temperatures for the carbon and high-speed steel.



Gale-Sawyer Electrically Welded End-mill

After welding and before the weld has been allowed to cool, the entire tool is heat-treated to relieve all strain, and it is then put through a special annealing process to bring both the high-speed and carbon steel to a workable point, after which the tool is finished in the usual way. In order to protect carbon steel from being destroyed at the high temperature necessary to harden high-speed steel, special furnaces have been built which provide for hardening the high-speed steel to any degree without damaging the carbon steel shank, which may be left entirely soft or hardened according to requirements of the customer.

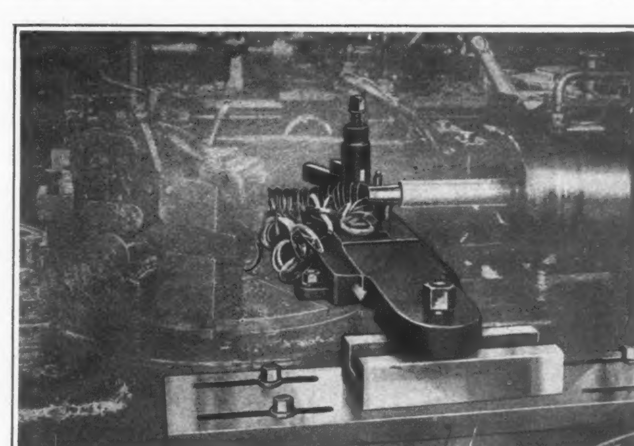
DU BOIS TOOLPOST COLLAR AND SHOE

A positive lock toolpost collar and shoe, which is of simple design and suitable for attachment to any standard toolpost without making alteration, has recently been developed and placed on the market by the Du Bois Machine Shop, Inc., 118 Hudson Ave., Albany, N. Y. The positive lock washer is a flat piece with recesses cut in it to suit the adjusting shoe. The adjusting "radius surfaces" on the collar and shoe are corrugated to afford a positive lock when the device is in use. This corrugation does away with the need of depending upon friction to hold the tool. The recesses cut in the washer or collar are of different heights to allow the tool to be set level at different heights. It is claimed that with this collar and shoe it is unnecessary to apply as great a strain on the clamp screw in order to secure the tool. Both the collar and shoe are drop-forgings made from a suitable grade of steel. These collars and shoes are made in different sizes to suit toolposts of different lathes.

Du Bois Positive Lock Toolpost Collar and Shoe

TAPER-TURNING ATTACHMENT FOR TURRET LATHE

The taper-turning attachment shown in the illustration is intended for use on any turret lathe for turning accurate tapers, especially long tapers that cannot be adequately taken care of by forming tools. The turning slide is bolted to the turret and the brackets that support the guide controlling its movement are bolted to the rear of the lathe. The attachment does not interfere with the general operation of the turret lathe, and when the taper is to be turned it is indexed to bring the taper-turning attachment into position; as the turret is



Taper-turning Attachment made by Matthew Harrison for Use on Turret Lathes

fed forward a roller stud attached to the turning slide engages the hardened steel guide-block adjustably mounted on the bracket at the rear. This guide-block may be swiveled and set to give any degree of taper. The operation of this device is exceedingly simple. As soon as the roller stud on the bottom of the slide of the turning attachment enters the guide-block, the slide is advanced or withdrawn, according to the inclination of the guide-block. At the end of the taper-turning operation the attachment is merely swung out of the way by the indexing until it is required for the next part that is to be machined. This attachment is built by Matthew Harrison, 61 Albemarle Ave., Springfield, Mass.

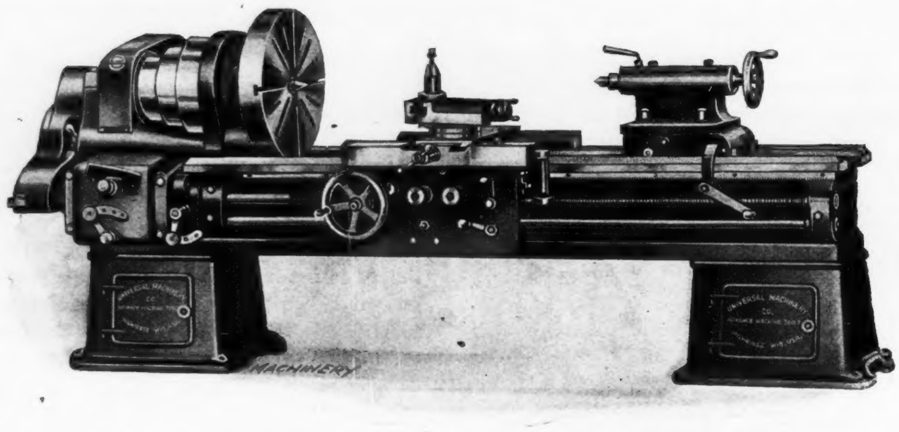


Fig. 3. Universal Machinery Co.'s 24-inch Engine Lathe with Quick-change Gear

"UNIVERSAL" LATHES

The Universal Machinery Co., 770-790 30th St., Milwaukee, Wis., is now building the high-speed all-geared manufacturing lathe shown in Fig. 1. The machine was especially designed to meet requirements in shops where the work is of a kind that calls for machining at high speed; and it is interesting to note that this lathe is sold under a guarantee that it will give satisfactory service when operated under spindle speeds up to 2000 revolutions per minute. The lathe is particularly suitable for use in the production of small parts where it is required to perform drilling operations and turning and boring operations on small diameters. It will be seen that the headstock is of the all-geared type with single-pulley drive, and where an individual electric motor is used, one good arrangement is to mount the motor at the back of the machine as shown.

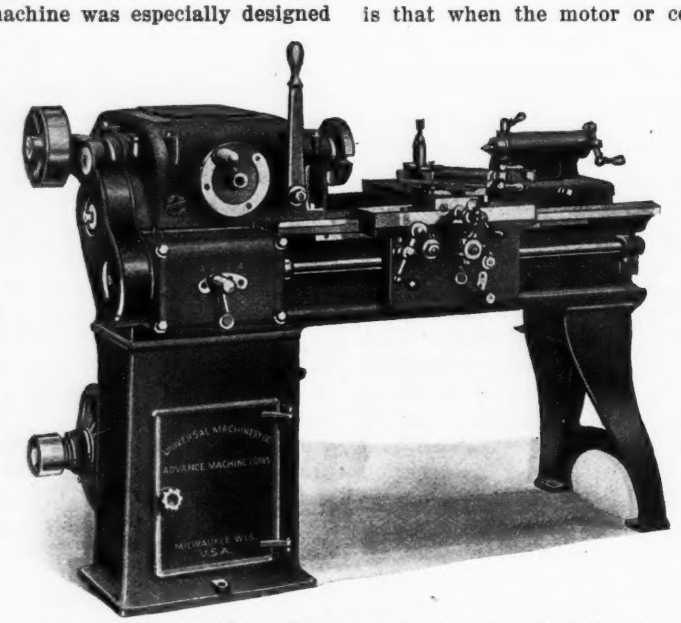


Fig. 1. High-speed All-geared Manufacturing Lathe built by Universal Machinery Co.

Eight geared speeds are obtained by means of a "radius plate" with four holes, which will be seen at the front of the head. These speeds may be arranged to give four forward and four reverse speeds, or eight forward speeds; and a set of frictions operated through the vertical lever at the front of the head controls starting, stopping and reversing of the spindle if the head is arranged for four forward and four reverse speeds, or starting and stopping the spindle if the machine is arranged for eight forward speeds. This allows the motor or countershaft to run constantly, thus giving the operator full control of the lathe at all times. Another feature is that when the motor or countershaft is running and the spindle is at rest, the only revolving parts are the main driving shaft and the two friction gears. The drive is said to be so sensitive that a half revolution of the spindle can be obtained when the spindle is running at 2000 revolutions per minute. All bearings are oiled through a double oiling system, *i. e.*, the combination of a splash system and felt wipers in each bearing. The oil reservoir is filled with 2½ gallons of oil, which is sufficient to take care of all oiling of the headstock, gears and bearings for a considerable length of time.

Longitudinal feed for the carriage is obtained and controlled through the all-geared feed-box, four mechanical changes of feed being obtained through a single lever, which will be seen at the front of the box. The tailstock is of the standard set-over type, allowing the compound rest to be swiveled at right angles to the carriage. When required, the lathe can be furnished with a turret toolpost, a turret on the carriage or a turret on the shears; and when the turret on the shears is employed, it may be furnished with or without power feed. When motor drive is employed, electrical apparatus, such as the controller or starting box, switches and cutouts, are placed in the cabinet leg, where they are out of the way of oil, dirt and chips; and the handle on the controller or starting box extends through a slot in the door, so that the operator has full control of his machine at all times. A taper attachment can be furnished for the lathe when it is to be employed on work requiring such equipment, and special fixtures can be designed to meet the requirements of manufacturing operations.

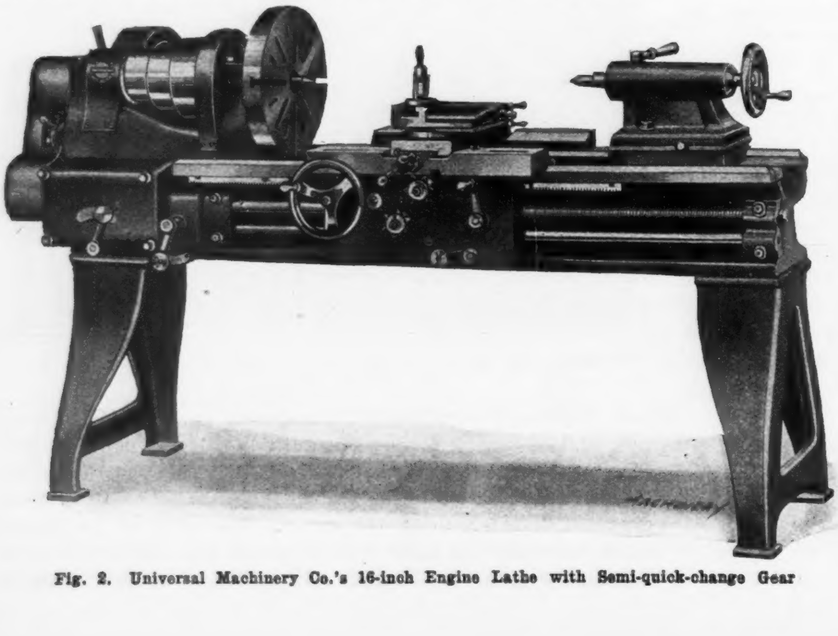


Fig. 2. Universal Machinery Co.'s 16-inch Engine Lathe with Semi-quick-change Gear

The Universal Machinery Co. is also building a line of "Advance" engine lathes, which are made in 16-, 18-, 22- and 24-inch swings. Each size of machine is built in semi-quick-change and quick-change types, both of which are driven by a three-step cone pulley.

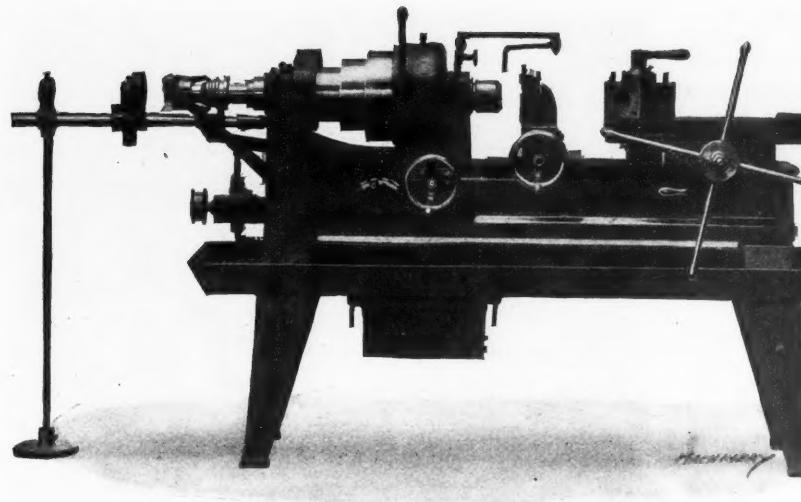


Fig. 4. Hand Screw Machine built by Universal Machinery Co.

and double back-gears. The general features of all the machines are similar, but the 16- and 18-inch machines are furnished with the usual form of legs, while the 22- and 24-inch machines have cabinet legs with liberal sized cupboards for the storage of tools, etc. Fig. 2 shows a 16-inch lathe of the semi-quick-change gear type, while Fig. 3 shows the 24-inch machine with quick-change gear mechanism. It will be noticed that these illustrations also show machines with the two styles of legs, and a good idea of features of the "Advance" lathes built by the Universal Machinery Co. will be gathered by making a study of these pictures, which clearly show general features of the two designs of engine lathes to which reference has already been made.

The dimensions of both the semi-quick-change and quick-change gear lathes of each size are the same, and an idea of the way in which these machines are built will be obtained from the dimensions of the smallest and largest machines of the line, *i. e.*, the 16-inch and the 24-inch lathes. For the 16-inch machines, the principal dimensions are as follows: swing over bed, 16½ inches; swing over carriage, 9⅜ inches; length of carriage bearing, 23½ inches; length of tailstock bearing, 10⅝ inches; dimensions of headstock cone pulley, 9¼, 8 and 6¾ inches by 3 inches face width; distance between centers for six-foot bed, 3 feet; size of front spindle bearing, 2 11/16 by 4 1/2 inches; size of rear spindle bearing, 1 15/16 by 3 1/4 inches; diameter of spindle nose, 2 3/8 inches; size of hole through spindle with No. 4 Morse taper, 1 3/8 inch diameter; range for thread cutting, 3 to 45 threads per inch; ratio of double back-gears, 4.4 to 1 and 9 to 1; and weight of machine with six-foot bed, 2000 pounds.

The principal dimensions of the 24-inch lathes are as follows: swing over bed, 24½ inches; swing over carriage, 15¾ inches; length of carriage bearing, 30 inches; length of tailstock bearing, 14 inches; dimensions of headstock cone pulley, 9¼, 12⅛ and 15 inches in diameter by 4 inches face width; distance between centers for six-foot bed, 3 feet, 10 inches; size of front spindle bearing, 3¾ inches by 7 5/16 inches; size of rear spindle bearing, 3 by 5 inches; diameter of hole through spindle with No. 6 Morse taper, 2⅛ inches; diameter of spindle nose, 3½ inches; size of lathe tool, ¾ by 1⅝ inch; ratio of double back-gears, 3.45 to 1 and 12 to 1; and weight of machine with eight-foot bed, 5190 pounds.

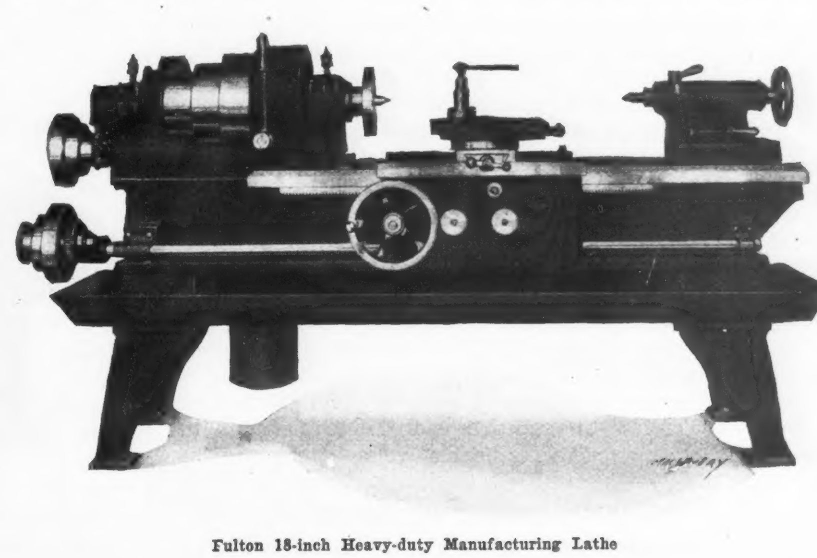
In Fig. 4 is shown the 1½-inch "Advance" hand screw machine which is another product of the Universal Machinery Co. A study of the illustration will make it apparent that this machine follows established practice in the design of hand screw machines, and on that account a description is not called for, as the picture will be sufficient to give any mechanic a good idea of the machine

FULTON MANUFACTURING LATHES

A recent product of the Fulton Machine Tool Co., 1438 Bryan Place, Chicago, Ill., is the heavy-duty manufacturing lathe illustrated and described herewith. This machine swings 18¼ inches and is usually built with a seven-foot bed. It was designed for use in shops requiring a simple high-power lathe for plain turning, boring and facing. The simplicity of the machine makes it particularly well adapted for work of this kind, and the range extends from very small parts up to the largest pieces that can be handled on an 18-inch lathe. As regularly built, the machine is equipped with a three-step cone pulley and single back-gears, but it can also be furnished with a friction head, by means of which the spindle is started and stopped with a powerful friction clutch operating in the largest step of the cone pulley. A hand-lever on the front of the headstock operates the friction and also applies a brake which instantly stops the spindle. The advantage of this arrangement is apparent, as it permits quick removal and replacing of work and quick stopping of the work to make measurements. Another special feature that may be furnished is a quick-acting tailstock; various types of rests may also be provided, as well as a taper attachment.

The headstock spindle is machined from a crucible steel forging, and is carried in phosphor-bronze bearings provided with ample facilities for lubrication. The front spindle bearing is 3 inches in diameter by 6¼ inches long. It will be seen that the tailstock is of the cut-away type, with two heavy bolts for clamping it to the bed. This tailstock can be set over for turning tapers, and it is furnished with a spindle 2⅜ inches in diameter by 9 inches long. The lathe is usually equipped with a special plain rest 7 inches wide, but it may be equipped with a compound rest or with a front and back plain rest. The apron is designed to provide front and rear bearings for all studs. This lathe has power, cross and longitudinal feeds, each of which is driven by an independent friction. The feed cones are of large diameter and carry a belt 1½ inch wide, which, in connection with a worm and worm-wheel in the apron, provides ample power for taking heavy cuts. Provision is made for adjusting the lower cone to obtain the desired belt tension.

The principal dimensions of this machine are as follows: swing over bed, 18¼ inches; swing over plain rest, 10½ inches; swing over compound rest, 12½ inches; length of bed, 7 feet; distance between centers with plain head, 38 inches; distance between centers with friction head, 36 inches; diameter of hole through spindle, 1 13/32 inch; diameter of spindle nose, 2⅝ inches; size of tool, ¾ by 1½ inch; length of carriage on bed, 24 inches; dimensions of cone pulley, 7¾, 10



Fulton 18-inch Heavy-duty Manufacturing Lathe

and 12¼ inches in diameter by 3½ inches face width; number of changes of spindle speed, twelve; range of spindle speeds, 23 to 303 R. P. M.; number of feed changes, six; range of feeds, 0.009 to 0.070 inch per revolution of the spindle; size of countershaft pulley, 14 inches in diameter by 4¼ inches face width; and weight of machine crated for shipment, 2650 pounds.

WESTINGHOUSE AUTO STARTERS

The three types of auto starters here shown have been developed by the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., for use in connection with the operation of large squirrel-cage induction motors up to 650 horsepower. They serve to provide ample protection to motor, machinery, line and operator, by preventing excessive strain on the motor and disturbance to the line, reducing the line voltage and current in starting. Both motor and starter are protected against overloads and short-circuits. In special cases, where the power delivered to the motor is of high kilovolt-ampere capacity, the destruction of motor and starter is prevented by the provision of heavy breaking capacity. Resistance can also be furnished to prevent the opening of the circuit when changing from starting to running position, which causes disturbances that may be injurious to both motor and starter.

These starters are extremely durable, and possess large, substantial contacts capable of breaking heavy currents frequently. The switching mechanism is simple and strong. The effect of arcing has been reduced to a minimum by immersing all contacts in oil and by the use of either auxiliary arcing tips or large contact area on the main contacts. Where arcing occurs, the contacts are provided with removable tips, which may be renewed readily with a pair of pliers. The starting current may be adjusted to the service by taps on an auto transformer, which provides either three or eight starting voltages, according to the capacity of the transformer. Absolute safety to the operator is assured by excellent insulation in the switch and by a liberal margin of safety above the actual requirements. Safety to the apparatus is assured by overload relays, which cause the switch to open at a predetermined overload, and by a low-voltage relay, which opens the switch when the voltage fails.

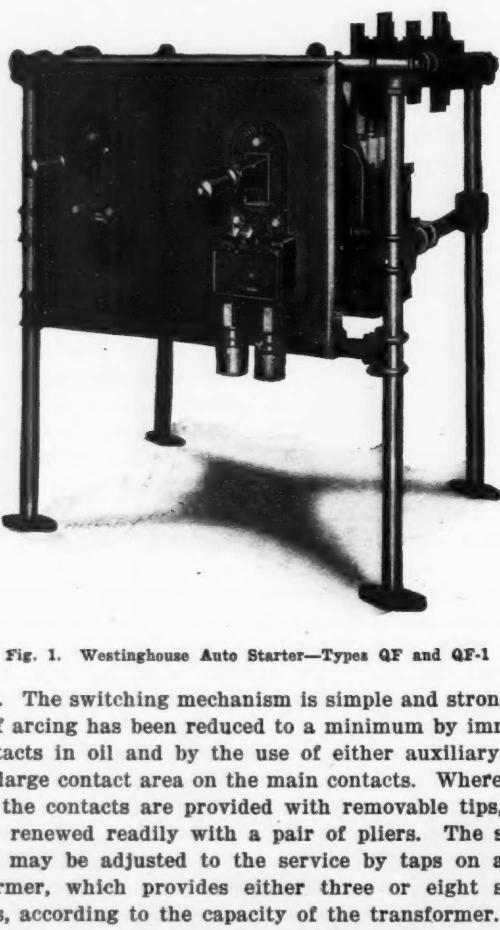


Fig. 1. Westinghouse Auto Starter—Types QF and QF-1

The three types of starters provide a range of capacities that will cover the majority of cases. The type Q starter is for use on two- and three-phase circuits of from 220 to 2200 volts, 25 to 60 cycles. The types QF and QF-1 are for use with motors of larger capacity or higher voltage than can be started by the type Q starters. They differ from the latter mainly in their ability to handle larger currents and in having larger kilovolt-ampere breaking capacity, and in certain sizes a preventive resistance. They also have two handles—one for starting and the other for running.

Fig. 2. Switches of Westinghouse Auto Starter

In starting a motor with the type Q auto starter, the switch handle is moved from the "off" to the "full up" position and held there until the motor has ceased to gain speed. It is then moved downward, as far as it will go, to the "running" position, where it will remain. The handle will not remain in the "starting" position unless held, and it is impossible to move the handle directly from the off to the running position without first passing to the starting position. Where a type QF or QF-1 auto starter is employed having no preventive resistance, it is necessary to move the starting handle down as far as it will go and hold it there until the motor has ceased to gain speed. That handle is then released, and before it has fully returned to the off position the running handle is moved down as far as it will go, where it will remain latched. If a preventive resistance is used, the starting handle is held down until the motor no longer gains speed; then the running switch is closed and the starting switch released.

Overload and low-voltage protection is furnished for all types, protecting the motor from overloads and from the effects of failure of the supply voltage. The overload relay operates very slowly on slight overloads and almost instantaneously on short-circuits. Consequently, the motor circuit is not opened for a momentary overload, such as during the moment of acceleration when the switch is changed from starting to running position. The low-voltage relay operates whether the voltage fails quickly or slowly, affording full protection.

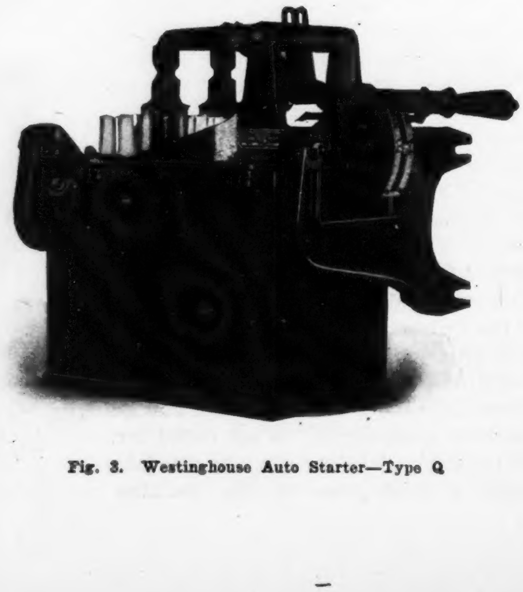
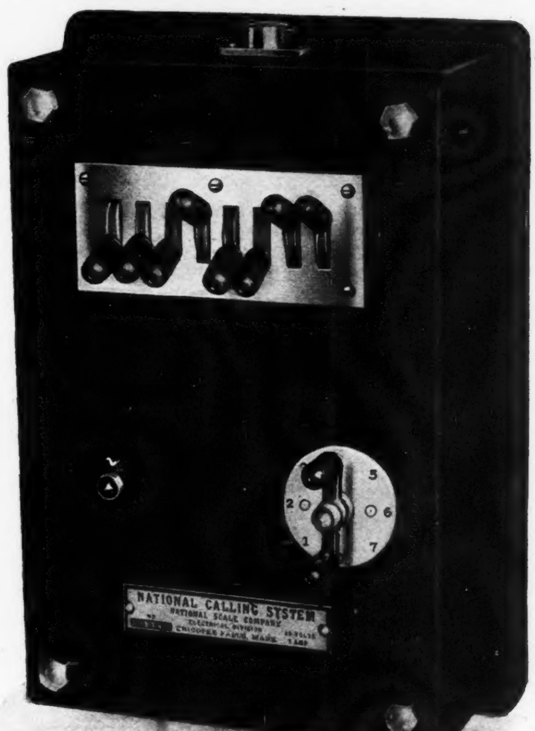


Fig. 3. Westinghouse Auto Starter—Type Q

NATIONAL CALLING SYSTEM

In manufacturing plants where the duties of certain executives require them to spend considerable time in the factory, and where it is frequently necessary to communicate with these men, some means must be provided for getting in touch with them. For this purpose the National Scale Co., 6 Mechanic St., Chicopee Falls, Mass., is now building a calling system that forms the subject of this article.

Primarily, this consists of an operating instrument which is placed beside the main telephone switchboard and taken care of by the same operator who has charge of the board. This instrument is connected by wiring to a line of signals, which may be either bells, horns, buzzers, lights or other electrical devices which it may be desired to use. These signals are distributed throughout the factory in such a way that each department is taken care of by one or more signals; and each man has a different signal. As a result, any executive who is going through the shop will instantly have his attention attracted by one of these devices giving his signal if the



Instrument placed by Telephone Switchboard and used to operate Bells, Buzzers, Horns, Signal Lights, etc., to call a Man to Telephone

switchboard operator desires to get him on the telephone. A great part of the high efficiency and productive capacity of the American business man is due to his faculty of utilizing his business day to the greatest possible advantage, and such utilization would be impossible were it not for the mechanical devices developed to facilitate the conduct of business transactions, of which the calling system is a typical example.

MERIDEN SENSITIVE TAPPING MACHINE

This sensitive tapping machine, a recent product of the Meriden Machine Tool Co., Meriden, Conn., is designed for tapping up to and including ¼-inch holes. Its great field of usefulness is found in electrical manufacturing, gun work, or any similar light tapping work on parts that are manufactured in large quantities. The machine is constructed along simple lines. The main tapping spindle is provided with two cones, which engage with a third cone carried by the main driving spindle. Power is transmitted to the tapping spindle by frictional contact of the two driven cones with the driving cone. The tap-carrying spindle has a free longitudinal movement, and when pressure is brought upon the end of the tap as a piece of work is moved toward it, the forward cone is brought into contact with the driving cone, causing the tap to rotate and do the tapping. As soon as the desired depth

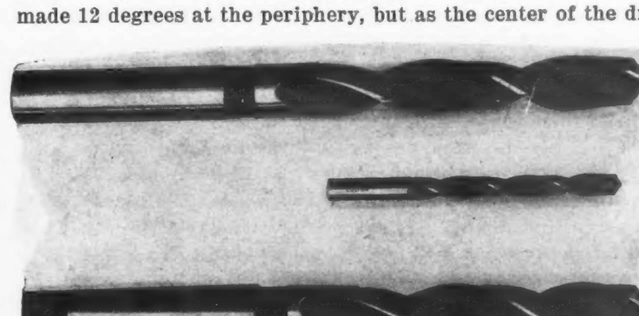
Sensitive Tapping Machine made by Meriden Machine Tool Co.

of tapping is reached, the natural tendency is to pull the work away from the tap, which slides the rear driven cone into contact with the driving cone, causing the tap to back out.

The two driven cones are made of cast iron, while the driving cone is cast iron faced with leather, which increases the effectiveness of the friction drive. The driving shaft is provided with a ball bearing thrust collar to overcome the thrust caused by the cones while in contact. The machine is provided with a fixture holding member that slides on V-shaped ways. To this member may be attached any work-holding fixture. It is provided with an adjustable stop rod that limits the travel of the work toward the tap. The machine may be furnished with or without the pedestal. The weight of the machine alone is approximately 100 pounds, and combined with the pedestal approximately 180 pounds.

"COLTON-DETROIT" TWIST DRILLS

Arthur Colton Co., Detroit, Mich., is now manufacturing the "Colton-Detroit" twist drills here illustrated and described. These are hammered high-speed drills designed for severe service; and they are claimed to be absolutely uniform in quality and uniformly hardened. Wide grooves in the drill provide adequate chip clearance which prevents tendency toward clogging. Another important feature is that on the taper shank drills the shanks are exceptionally large so that ample strength is provided. The drills are ground at the point with cutting edges of equal length, that make a uniform angle with the longitudinal axis of the drill, 59 degrees being considered the best angle for this purpose. The lip clearance or backing-off of the cutting edges for regular shop work is made 12 degrees at the periphery, but as the center of the drill



"Colton-Detroit" Twist Drills with Straight and Taper Shanks

is approached this angle is increased until the line across the center of the web makes an angle of 135 degrees with the cutting edges. For heavier feeds or drilling soft metal, the angle of the lip clearance may be increased to 15 degrees at the periphery, but in such a case it is important that the angle at the center be given a corresponding increase. For drilling extremely hard material where lighter feed is used, the point should be ground at an angle of 68 degrees, while the angle of lip clearance is decreased to 9 degrees at the periphery. These drills are made in a wide range of sizes and with both taper shanks and straight shanks.

LANGELIER DUPLEX MULTIPLE DRILLING MACHINE

The illustrations which accompany the following description show a double-acting horizontal multiple drilling machine recently brought out by the Langelier Mfg. Co., Providence, R. I. This machine was designed for drilling such parts as motorcycle, bicycle and side car hubs, or for any cylindrical parts requiring one or several holes at opposite ends. The outstanding feature of the machine is simplicity, both as regards operation and general design. The multiple heads, which are interchangeable, are carried in sliding housings, both of which are actuated simultaneously by a single hand-feed lever, compounded to obtain the required leverage.

Fig. 1. Langelier Double-acting Horizontal Multiple Drilling Machine

Drive is transmitted through floating pulleys mounted in brackets at each end of the bed. A double-splined spindle slides in the pulley, transmitting the drive to the multiple heads and permitting free motion of the housings. This construction eliminates all belt pull on the spindles, so that they carry no other load than that required for driving the heads.

The jigging is simple and remarkably rapid. The jigs, one to each multiple head, are self-contained with the heads, being located by a central keyed spring plunger. The jig on the right-hand head contains an indexing device. Slipping the work loosely into either jig, the heads are brought together by a movement of the feed lever. This clamps the work between the jigs, while continuing the travel of the heads feeds the drills into and through the work, the spring plungers receding into the heads. As the holes are on very close centers, only every alternate hole is drilled at one operation. After withdrawing the drills, the work is indexed by a twist of the wrist, a spring plunger engaging one of the holes already drilled; then a second operation completes the circle. A new piece may be inserted the instant the drills are withdrawn, as the open construction permits the finished piece to drop into the chip pan, where it may be removed while the next piece is being drilled. The machine drills two sizes of hubs, so that two sets of interchangeable heads are provided. The unit construction of the multiple head practically eliminates any setting up, as the heads may be interchanged in a few minutes. By test, the first three samples drilled were finished inside of one minute, there being a total of thirty-six holes per

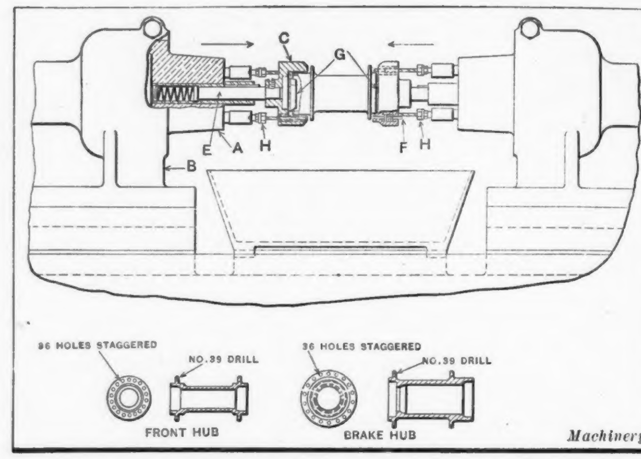


Fig. 2. Sectional View of Jigs for drilling Rear or Brake Hub

hub, using a No. 39 drill. This is at the rate of 6480 holes per hour.

Micrometer adjustment is provided for the drills by means of adjustable collets, while a single adjustable stop, shown at the left-hand end of the machine, suffices for both heads. Fig. 2 shows a section through the jigs for the rear or brake hub. *A* is the multiple head, contained in the sliding housing *B*. The jigs are shown at *C*, the plunger receding into the head as shown at *E*. The index pin is shown at *F* in the right-hand jig. The work is located and held by the three-point centers *G*, the springs having sufficient tension for a firm grip, while the several drills entirely neutralize any tendency to creep. The adjustable collets are shown at *H*. Automatic oil feed is provided, driven from an overhead countershaft which is furnished with the machine. While peculiarly suited to the class of work described, the machine may readily be adapted to a wide range of work of practically any shape within the capacity of the heads, as jigs may be attached to the bed in place of the chip pan shown.

"REID" SURFACE GRINDER

The increasing demand for surface grinding machines has led the Boston Scale & Machine Co., 381-389 Congress St., Boston, Mass., to place on the market the machine shown in the accompanying illustration. This is known as the "No. 2 Reid

"Reid" Surface Grinder built by Boston Scale & Machine Co.

surface grinder," and is intended for production grinding as well as for the general run of tool-room grinding handled by machines of similar capacity. It will grind work up to 18 inches in length, 6 inches in width, and 12 inches in height.

The wheel-spindle is of steel, hardened, ground and lapped, and runs in phosphor-bronze bearings, which are provided with means for taking up wear. It is raised and lowered by means of a handwheel that may be seen at the top of the machine, and this wheel is graduated to read to 0.0005 inch. The wheel-spindle is designed to take wheels up to 7 inches in diameter, ½-inch face and ¾-inch hole.

The work-table is 46 inches long, 8 inches wide, and has a working surface 18 inches long by 6 inches wide, which is provided with three T-slots. The power longitudinal feed to the table is 18 inches and the power cross-feed is 6 inches. The table travel is automatic in either direction and reversal is brought about by means of dogs at the front side of the table that trip the reversing lever. When desired, the reversing lever may be thrown out and the table moved beyond the reversing point without interfering with the dog adjustment.

The transverse movement of the table is automatic and the feed may be set to operate at the end of each stroke or at the end of each complete forward and return stroke. The feed can be easily changed from one direction to the other. The amount of feed may be varied from 0.007 to 0.084 inch, and it is not a friction feed, but is positive in its action. A feature of the machine is the method of quickly starting or stopping the machine at will by a push-rod that operates from the center of the longitudinal hand-feed. Pulling this rod out starts the machine, and pressing it in stops it instantly.

The countershaft furnished with the machine has tight and loose pulleys 8 inches in diameter, and a 3-inch belt is recommended. The countershaft should operate at 360 revolutions per minute. The floor space of the machine is 65 by 30 inches, and the net weight, 1300 pounds. The shipping dimensions are 40 by 35 by 72 inches, occupying 58 cubic feet of space, and the shipping weight is 1600 pounds.

RICKERT-SHAFER RADIAL TAPPING MACHINE

A machine known as a ½-inch Model R or radial tapper is a recent product of the Rickert-Shafer Co., 612 W. 12th St., Erie, Pa. The machine has a capacity for tapping any hole within a radius of 48 inches, and the arms can be folded to provide for tapping holes as close as 8 inches from the column. The arms swing on ball thrust bearings, making the machine easily handled; and it is said to be so sensitive that the point of the tap will readily align the spindle with the hole to be tapped. The spindle is driven by a friction drive consisting of an aluminum disk which has essentially the same coefficient of friction as cast iron, although its centrifugal force is only about one-third as great. This friction disk is placed between two paper frictions and may be brought into contact with either the driving or reversing friction by pressure applied to the operating lever. Adjustment is so regulated that the spindle is in motion before the tap is brought into contact with the work, although it is revolving only while the machine is in operation. All spindle thrusts are taken by a series of S. K. F. ball thrust bearings.

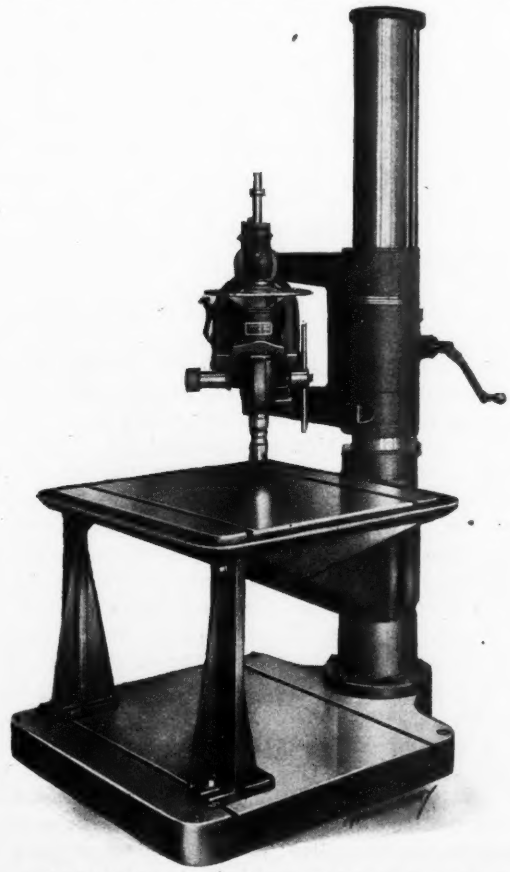


Fig. 1. Rickert-Shafer Radial Tapping Machine with Double Arm folded

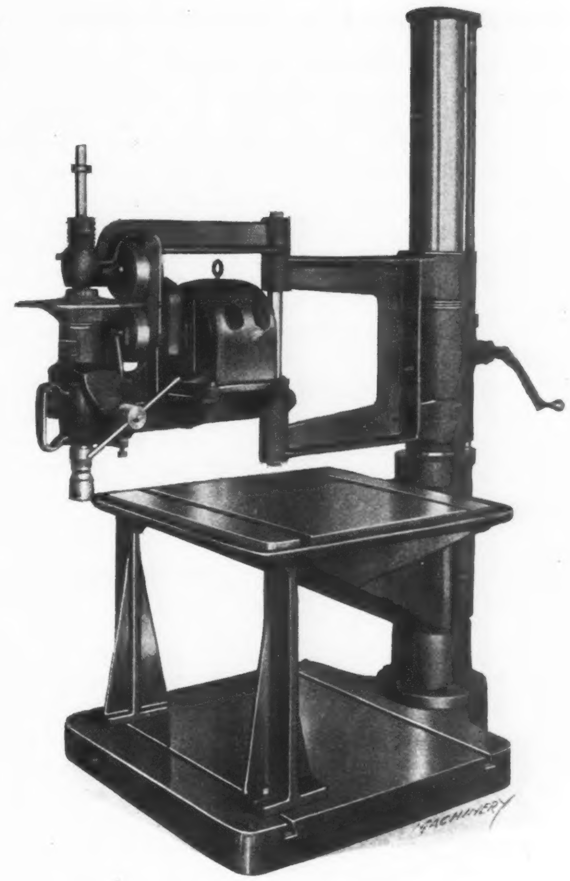


Fig. 2. Rickert-Shafer Radial Tapping Machine with Double Arm extended

These machines are equipped with a direct-connected motor, the motor being set back of the spindle to drive the frictions through bronze intermediate gears. By placing the motor in the spindle head instead of driving through gears and shafts or belts from a position back of the machine, all tendency for the arms to double up under the heavy pull is entirely eliminated, and there are no belts or other parts to require attention. These machines may be furnished with either a plain table or a swivel table. The plain table is used for work in which all holes are tapped square with the bottom of the work, while the swivel table is employed for handling angular work, such as the holes in eight- and twelve-cylinder crank-cases. The machines are equipped with either a positive drive tapping chuck or a quick-change chuck for use in case more than one size of hole is to be tapped in the same piece. All work up to 22 inches high can be tapped on the table, while work up to 46 inches high can be tapped on the base by swinging the table out of the way. The table has a working surface 30 by 30 inches square, while the base has a working surface 36 by 36 inches in size. These machines have a capacity for tapping holes in steel from ¼ to ½ inch, and when tapping in cast iron they are capable of taking care of holes from ¼ to ⅝ inch in diameter. The weight of the machine is approximately 2000 pounds.

PEERLESS CUTTING-OFF SAW

The Peerless Machine Co., 1611 Racine St., Racine, Wis., has recently developed a line of high-speed heavy-duty cutting-off saws. The principles embodied in these tools enable them to meet the demand for cutting the largest sized materials, and yet they are so sensitive that the smallest sizes can be cut as readily. The illustrations give an idea of the rigidity of these tools. The principal feature is the manner of controlling the saw guide, which it will be noted is overbalanced by four coil springs. These springs are mounted in such a position that no strain is left on the bearings, thereby making it very sensitive in its movement. The springs tend to bring the saw frame upward.

The feeding mechanism consists of a ratchet bar and a set of dogs. The dogs are mounted in one end of an oscillating arm, and the other end has a roller that engages with a cam on the crankshaft, the roller being forced against the cam by a spring. Changing the tension of the spring increases the feed pressure which is entirely controlled by the lever shown on the left-hand side of the machine. When the lever is at the bottom, the feed is entirely relieved, and when the machine is in operation the saw frame will not feed down. The moment a little tension is put onto the feed spring the frame feeds down. When the saw frame has completed its cutting stroke, the cam forces the roller down, which relieves the tension on the feed spring, and as the saw frame is overbalanced, allows it to rise and clear the work until the cutting stroke commences again. At this point the cam runs off the roller, allowing the spring to force up on the oscillating arm, and the other end to pull down on the ratchet bar. The two ratchet dogs alternately engage on each thirty-second movement of the ratchet bar. This insures uniform feed pressure on the blade throughout the entire cut; otherwise the feed spring tension would be greater either at the beginning of the cut or at the end.

It will also be understood that in this type of feeding mechanism there is no friction, nothing to wear or slip, whether the spring is under full tension or no tension. Whatever point the feed lever is set at the feed remains uniform, just the same as if a weight were hung onto the frame for feeding. In case the machine is accidentally or intentionally

Fig. 1. Peerless High-speed Heavy-duty Cutting-off Saw

started while the saw blade is above the work it will feed right onto the work, using up the full movement of the cam until the blade comes in contact with the work; then the feed is decreased to whatever the blade will cut. If the blade should break, it again feeds right down the full movement of the cam until it comes in contact with the automatic stop; then the feeding mechanism is automatically released and the belt shifts onto the loose pulley. As the saw frame is overbalanced, it will then automatically rise to the height at which the gage is set. This relieves the operator of raising a heavily weighted cumbersome saw frame. All that is necessary for him to do is to loosen the vise, move the stock ahead and pull the belt-shifting lever forward. It will also be understood, owing to the frame being overbalanced so the movement is always upward, instead of down, that there is never any possible chance of the saw dragging on the idle stroke, regardless of the stopping or starting position of the crank. With this construction the saw frame can never drop in case the blade breaks, which may not only cause accidents to the machine but to the operator as well.

The feeding mechanism is connected with the belt-shifting lever and does not engage the feed until the belt has been

Fig. 2. Opposite Side of Peerless Saw shown in Fig. 1

shifted three-fourths onto the tight pulley. This allows the machine to get up full speed and the cutting compound to flow onto the work before the blade comes in contact, which is an important feature in this type of machinery. If a blade is allowed to make two or three strokes dry over the work before the compound flows, it affects the temper of the teeth and then the blade is condemned. This gives the operator complete control of the machine by the use of one hand, as he does not have to hold onto the saw frame with one hand while starting with the other. The feeding mechanism is so sensitive that the blade can be brought onto the work so it merely touches, making it well suited for cutting delicate work or when commencing cutting on square stock. This is accomplished by the feed lever shown on the left-hand side of the machine. The saw frame is all in one casting, as well as the saw guide, making it impossible to get out of alignment. Provision is also made for taking up wear in the saw frame slide.

This machine is driven by a set of reducing gears, four to one, which allows for a good sized driving pulley on the main shaft. A large gear is keyed onto the crankshaft and the pinion and driving pulley are cast in one. The crankshaft is made of steel, being of the center crank type, having two extra long bearings, making a substantial drive. All bearings are large, allowing the machine to be worked to its full capacity without the least vibration in any of its mechanism. The rear vise jaw swivels, allowing for miter work to be cut. The front vise jaw is of a quick-acting type, provided with a handwheel for quick adjustment on square and a ratchet handle for powerful grip. The saw blade holders are of special design, allowing different length blades to be used according to the size of stock cut. The height gage, which is located on the right-hand side of the machine, can be set so the saw frame automatically rises to whatever height the stock is being cut. A depth gage is also provided for allowing the machine to stop automatically at any depth of cut. A notched segment on the left-hand side of the machine for controlling the feed is provided with a stop gage so the same feed pressure can be applied; on some classes of work it may be necessary to relieve this feed lever in order to start the cut,

and the lever can then always be brought back to the same position.

In the cabinet base is located a brass gear pump for circulating the cutting compound onto the blade. The nozzle for distributing the compound is locked in position by thumb-screws, allowing for adjustment either way; therefore, there is no danger of its jarring loose, allowing the nozzle to move and the blade to run dry and be ruined. The saw table has two T-slots, one on each side of the blade, allowing for irregular work to be bolted onto the table. The T-slot next to the saw blade is provided with two movable angle-plates, preventing work from rolling after being cut off. A tray for collecting compound and returning it to the cabinet base is extra deep, making lots of room for saw chips and no danger of compound flowing over onto the floor. These machines are also designed for direct motor drive and with six-speed gear-boxes. The illustrations represent a machine with a capacity for 13- by 16-inch stock, and it weighs approximately 1800 pounds.

S. A. & S. RECALESCENCE POINT FINDER

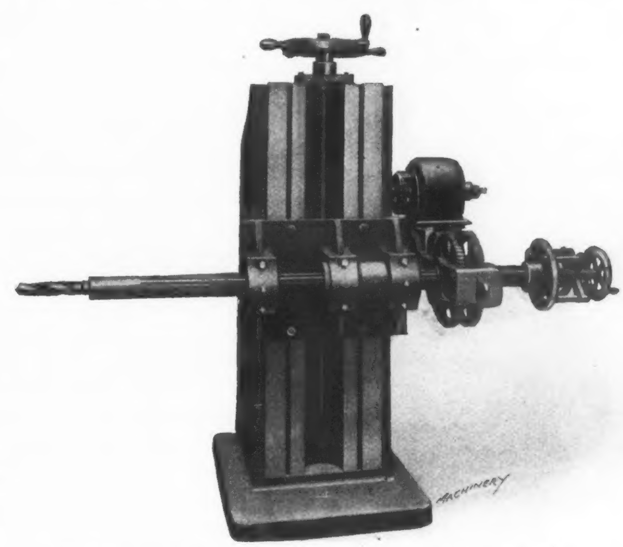
A tool is heated and quenched in oil or water to make it harder. Raising the temperature of the steel causes changes in the chemical arrangement of the elements composing the steel after the temperature has been raised to a sufficient degree. These changes are responsible for the results obtained by the well-known processes of hardening and tempering. If a piece of steel that has once been heated to a sufficient temperature to produce hardening is allowed to cool very slowly, these changes of chemical composition take place in the reverse direction, so that the steel comes back to its original condition; but if the heated tool is cooled quickly, *i. e.*, quenched immediately after removing it from the furnace, the changes in chemical composition are permanent and result in the hardening of the steel.

In addition to the line of internal and external grinders and the small tools made by the Slocum, Avram & Slocum Laboratories, Inc., 531-539 W. 21st St., New York City, this firm is also manufacturing a recalescence point finder for use in hardening tools. This is one of the first tools that has been put on the market which commercializes in an adaptable form the well-known fact that all tool steels lose their power of attracting a magnet during the interval between the decalescence and recalescence points. The Slocum, Avram & Slocum recalescence point finder consists of a specially constructed magnet, which is of compact form and carefully balanced on the brass arm, to allow the attraction of magnetic force to be shown up to the time the decalescence point is reached. At this point the steel which is being heated entirely loses its power of magnetic attraction and then reaches—at a temperature of from 85 degrees to 100 degrees F. beyond this decalescence point—that correct critical point at which the steel should be quenched.

For shop use this is a very practical way of determining the so-called "critical point" or proper temperature at which steels should be quenched in conducting the hardening operation. To make it as convenient as possible to use in the shop, the Slocum, Avram & Slocum recalescence point finder is packed in a serviceable case and provided with interchangeable extensions for the arm, making it possible for the operator to quickly apply the tool either in a gas furnace of the smallest or largest type, or to use it over an open coal-heated forge. The practicability of adapting this tool for general work in shops that are not equipped with pyrometers should commend it to attention. It is claimed to be a substitute for the pyrometer, but is valuable for use in small shops where there is not enough work to warrant the installation of an expensive pyrometer equipment.

PEDRICK COLUMN BORING MACHINE

The Pedrick Tool & Machine Co., 3639 Lawrence St., Philadelphia, Pa., is now building a column-type boring machine, which is illustrated and described herewith. This machine consists of a boring-bar mounted in a saddle which is moved vertically on the column, and it is also planned to furnish a machine of this form to be used on a floor-plate. Another variation would be to construct the machine with an outer support for the bar and with the machine proper mounted on a long bed at right angles to the bar, to provide for drilling or boring parallel holes in a piece of work. The portability of the machine serves many useful purposes when working on large pieces. Another feature is simplicity of the design, which enables the machine to be built at a moderate cost,



Column Type of Boring Machine built by Pedrick Tool & Machine Co.

although it has a fairly wide range. A powerful train of compound gears drives the boring-bar, power being furnished by an electric motor. By using different sizes of gears, various speed changes may be obtained.

In order to describe the operation of this machine, it is first necessary to describe the boring-bar, because it is the operation of this bar that differentiates the machine from other types of boring equipment on the market. The standard Pedrick portable boring-bar carries a square-thread feed-screw in a groove in the bar. This screw is supported in bronze bearings of special design which provide for taking the thrust. In re-boring cylinders and performing similar operations, the bar is held in bearings at both ends of the cylinder and a cutter-head engaging the feed-screw by a half-nut travels along the bar while performing the boring operation.

In the new column-type boring machine which forms the subject of this description, the same action is possible, the bar being supported at the outer end by a column of conventional design with an adjustable bearing to provide for aligning the bar. The advantages of boring in this manner are clearly apparent, as the bar does not have to be twice the length of the work and the work can be brought close to the main bearing so that the bar is rigidly supported. In this way larger work can be handled, a machine with a 3½-inch bar being capable of boring holes 24 inches in diameter. This method has been termed boring with a "fixed" bar.

Heretofore it has not been possible to use this type of boring-bar for any operation through which the bar could not be passed. Conditions have often called for a bar to bore long holes, but owing to the construction, the smallest diameter of the bar is limited, because the feed-screw would be too weak to give much service. A method has just been developed for making this type of bar travel like the spindle of a drill press or boring machine, thereby avoiding the limitation just referred to. This is accomplished without the use of additional mechanism, and the bar may be converted from a fixed bar to a traveling bar almost instantly. When the machine is used with the bar traveling, it possesses the same characteristics as the standard boring machines.

In the end of the bar there is a Morse taper hole for the insertion of different tools and appliances, and either drills or auxiliary bars may be used. By this means the machine will bore or drill holes smaller than the diameter of the main

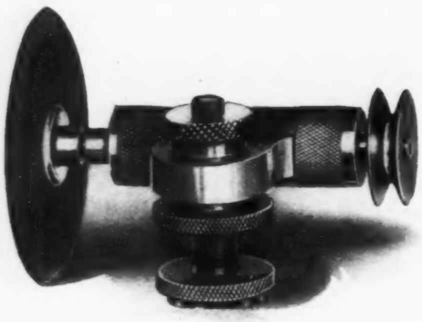


Fig. 1. External Grinding Attachment

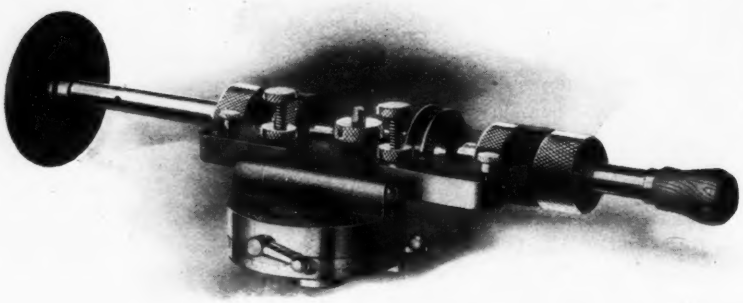


Fig. 2. Internal Grinding Attachment

bar. Imagine a piece of work having five bearings three or four inches in diameter, located at intervals of five feet. In machining this work, a suitable auxiliary bar is passed through the bearings and fitted to the end of the main bar, allowing the bearings to be bored consecutively. The work may be done accurately without requiring the use of a large boring mill, and attention is called to the fact that the machine may be taken to the work instead of requiring the work to be brought to the machine. The principal dimensions are: minimum distance from center of bar to floor-plate, 14½ inches; maximum distance from center of bar to floor-plate, 56½ inches; size of baseplate, 48 by 29 inches; size of saddle, 25 by 18 inches; vertical travel of saddle on column, 42 inches; and net weight of machine, 4200 pounds.

S. A. & S. GRINDING ATTACHMENTS AND TOOL-ROOM SPECIALTIES

The Slocum, Avram & Slocum Laboratories, Inc., of 531-539 W. 21st St., New York City, have developed a line of external and internal high-speed precision grinding attachments for bench lathe use, which are also applicable to the lighter types of engine lathes. The external grinder is shown in Fig. 1, from which it may be seen that, exclusive of the post, there are but six actual working parts. This attachment is held in the toolpost of the lathe with a special form of elevating screw that permits the grinding wheel to be adjusted with relation to the center of the work without loosening the post itself. This method of mounting also provides for swiveling the entire attachment without affecting the vertical adjustment. This type of base mounting is so designed that it supports the grinding spindle mounting, so that chatter is impossible.

The construction of the spindle, which permits of a speed of 8500 R. P. M. without heating, is interesting. The spindle and its bearings are both of tool steel, hardened and ground, thus furnishing the best possible bearing surfaces. The spindle diameter is 5/16 inch, and the double taper bearings are 3/4 inch in length. The bearing at one end is integral with the spindle, and the other bearing is a bushing that may be adjusted to take up wear. To provide adequate lubrication, the body of the fixture is bored out to form a generous pocket from which oil runs to the bearings as needed. The bearings at both ends are protected with brass dust-caps that exclude all dirt and grinding dust.

This grinding attachment will carry wheels up to 4 inches in diameter and is adapted for the precision grinding of centers, plug gages, spindles and other tools requiring similar precision. The wheels for this attachment are mounted on taper arbors that may be readily inserted in the spindle without disturbing the mounting. By using a number of these taper wheel-arbors, wheels may be instantly changed without removal from mountings.

Internal Grinding Attachment

The internal grinding attachment is illustrated in Fig. 2. This attachment is designed for high-speed precision internal grinding, driving the wheels at sufficient speed to obtain their most efficient cutting qualities, and particular care has been taken to guard against chatter. A feature of this attachment is the graduated swivel base that is especially valuable in grinding compound tapers, as it may be used in conjunction with the compound rest of the lathe. The compound rest may be set to one taper, while the graduated base of the attachment may be changed quickly to agree with the second taper.

A second feature is the provision that enables the operator to draw the grinding wheel instantly away from the work at any stage of the grinding operation, thus allowing him to quickly and accurately measure the work in hand without interference from the wheel. This is accomplished by a hinge connecting the head that carries the grinding-wheel spindle mounting with the base of the fixture. Adequate provision is made for return to the identical position where the operation left off by using hardened elevating adjusting screws. A clamping screw locks the hinge and holds the fixture securely in the grinding position.

The construction of the spindle is of interest, and is similar to that of the external grinder, except that the bearings are very widely spaced. This spindle is 7/16 inch in diameter, made of tool steel, hardened and ground. The spindle does not turn in its bearings, but slides in bearing sleeves, which, in turn, rotate in the bearings. Tool-steel balls at the base of the set-screws in these sleeves allow the spindle to slide but not to rotate. This sliding action forms the only source of wear upon the spindle. As in the case of the external grinding attachment, the spindle is provided with a taper socket to receive wheel-arbors. The spindle is fed longitudinally by hand, and because of its special mounting is very sensitive in its action.

The spindle bearings are made of tool steel, and like the tool-steel spindle, are hardened and ground. These sleeve-like bearings are ¾ inch long and provided with a double taper that allows perfectly free rotation, yet without end play. Adequate protection of the bearings against dirt and dust is afforded by brass bearing caps. The oil reservoir in the internal grinding attachment is even more adequate than in the external attachment, for a deep reservoir runs back into the body, and oil is supplied through dust-proof oil cups.

Toolmaker's Square with Indicator

The indicating toolmaker's square shown in Fig. 3 is a device for determining instantly how many degrees a piece of work is out of square. Formerly it was necessary for the toolmaker to hold a solid square on the work before a light and judge the variation from 90 degrees by his eye. With this new indicating square this is not necessary, as it determines at once how many degrees the work is out. The engaging pin is for making it into a perfect square and holding it to a fixed angle of 90 degrees.

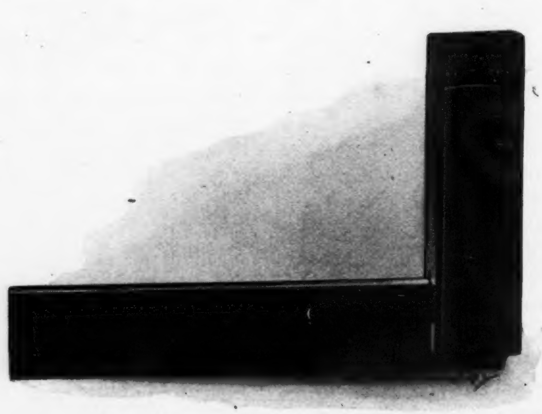


Fig. 3. Indicating Toolmaker Square

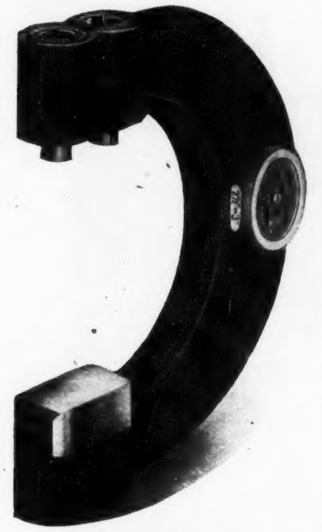


Fig. 4. Adjustable Limit Snap Gage

In addition, there is a thumbscrew that permits the blade to be locked at any desired angle up to 10 degrees plus or minus, thus making the square to all intents and purposes an angle gage. The blade is hardened and ground and has two knife-edges, so that the outside or inside edge of the square may be used at will. In general appearance, the square resembles a solid square, as all the mechanism is within the stock, but the interior is readily accessible by withdrawing a slide from either side.

Adjustable Limit Snap Gage

The adjustable limit snap gage shown in Fig. 4 has an interchangeable but solid anvil base made of tool steel, hardened, ground and lapped. This lower flat anvil is so balanced in its proportions that it provides a supporting surface from which the gaging operation may be started, thus bringing the brunt of the gaging contact on this generous anvil block and not on the gaging points above. The two gaging plugs may be set to "Go" and "Not Go" sizes quickly, and when once set may be readily sealed by the gage inspector. The body of the gage is made of a fine close-grained gray iron casting. Before being machined the gage castings are thoroughly seasoned, and while heavy enough to withstand shop use, they are as light as an efficient gage of this type should be. A fiber finger grip on each side of the gage prevents expansion due to heating in the hand. The size of the gage is stamped in inches below the fiber grip on each side. The tool-steel plugs and anvil are made as individual units, ground and lapped before assembling, and are interchangeable.

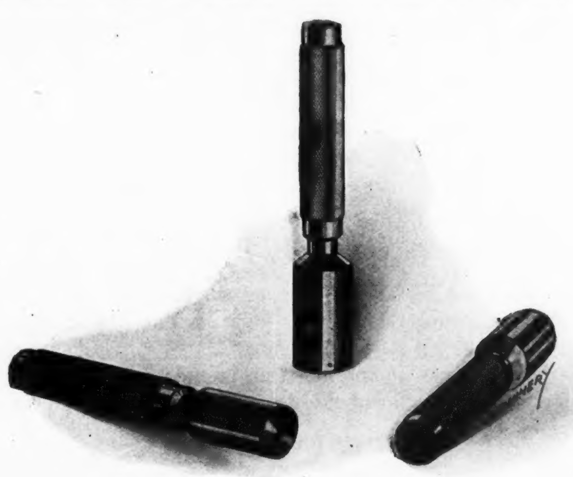


Fig. 5. Interchangeable Plug Gages

Interchangeable Plug Gages

Fig. 5 shows one gage from a line of interchangeable plug gages made by the company. These plugs have a two-piece screw-head which operates the plug forward or back as desired. The plug is lapped and closely fitted to the screw head by a spring lock-washer, uniting the plug to the screw as a single unit. The handle is of cold-rolled steel left soft, while the plug itself is of hardened, ground and lapped tool steel. The handle is hollow, and the gages proper have taper shanks that fit into the taper socket of the handle. This gage is most flexible in its adaptability, as one handle can be used for several gages. The saving in steel is considerable and the lightened handle makes the gage sensitive to handle. Provision is made for pinning the gage to the handle when deemed advisable. The gage is adaptable for use on plug thread gaging, and when desired can be furnished in the double-end type in which the "Go" and "Not Go" ends may be used in the same handle.

Sine Bar Fixture

Fig. 6 shows the type of sine bar that the S. A. S. Laboratories are building. This sine bar is universal in its use, the distinguishing feature being the method employed for facilitating the setting of the bar in the desired position. The bar has one end fixed, and can be readily set at any angle by swinging the bar up or down, the lower button, which is constant, acting as the fulcrum, while the upper button slides in the radial slot. After the bar is set, the work can be easily clamped in position by the holes shown. This sine bar is made in different sizes, covering all toolmaking requirements.

Thread Measuring Machine

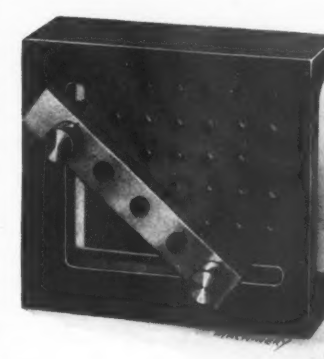


Fig. 6. Improved Type of Sine Bar

In Fig. 7 is the new thread measuring machine for checking such work as plug gages, etc., by the three-wire system. The work is held on a central arbor that runs in bushed holes in the fixture. At right angles to the work is a deep slot in the fixture that terminates in a T-slot. In this slot slides a special micrometer caliper; the measuring points of this caliper are on a plane with the center line of the arbor, and as the caliper is keyed in the T-slot, it always retains its alignment. The micrometer is set by means of Johansson gages, the gage to be measured being placed in position and the right wires slipped between the gage and the measuring points. This method eliminates the trouble usually encountered in holding the wires in place by means of elastic bands, and insures perfect measurement. When testing concentricity, the work is easily rotated on the arbor without disturbing the alignment.

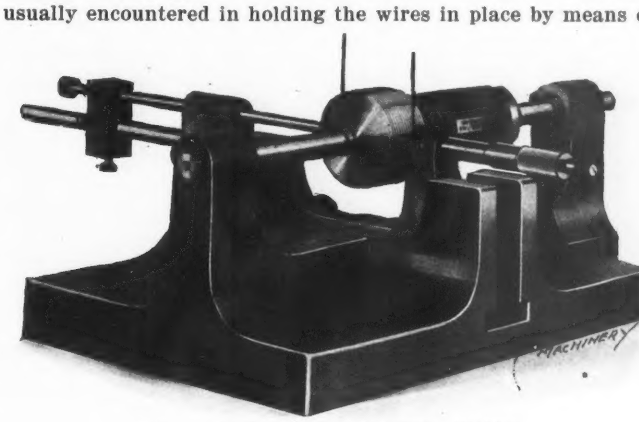
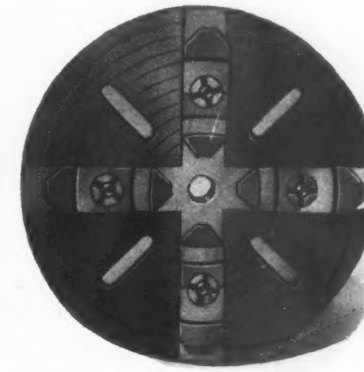


Fig. 7. Precision Thread Measuring Machine

SIMPLEX INDEPENDENT CHUCK

Some users of independent chucks have experienced trouble through loss of gripping power after the chucks have been in use for some time, because there are no means of taking up lost motion between the jaws and their guides. With the view of overcoming possible trouble from this source, the Simplex Tool Co., Woonsocket, R. I., has designed an independent chuck, which is illustrated and described herewith. The body is



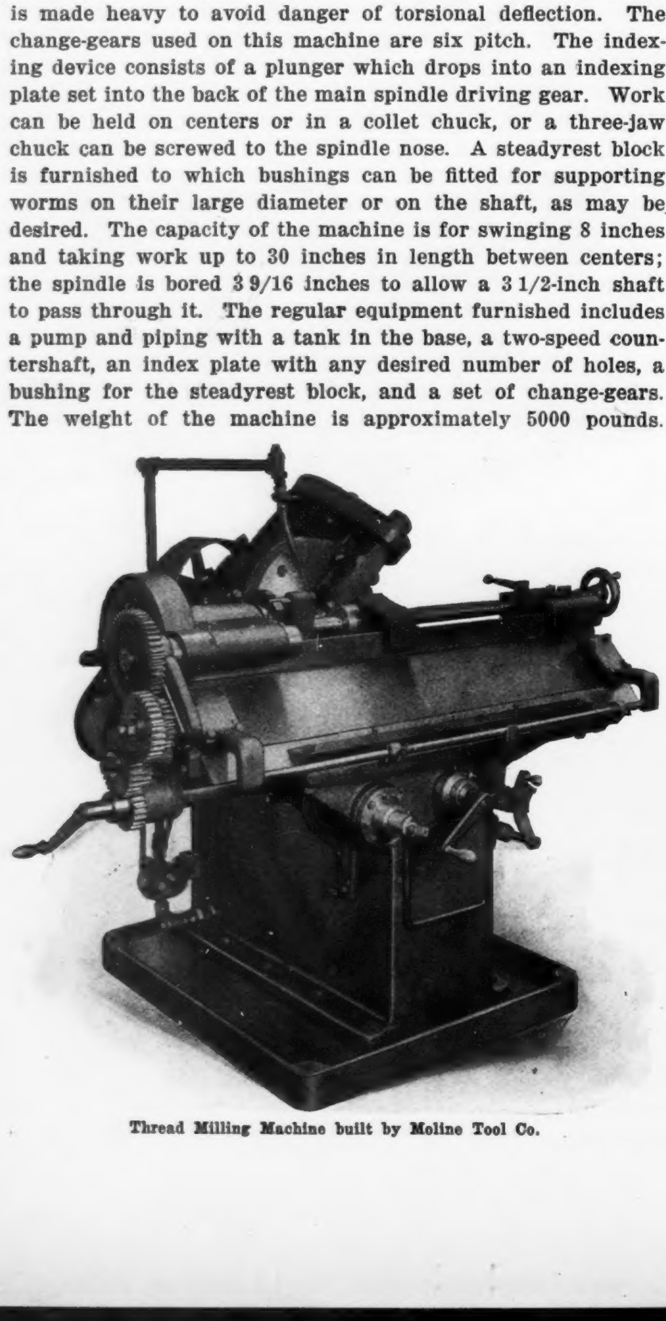
Simplex Four-jaw Independent Chuck

made of high-grade cast iron and the jaw ways are deeply planed across the face. These jaws are separably reversible and are so constructed that any backlash which develops is automatically adjusted. All screws are made from forgings and turned all over; they are hardened and tempered to give the desired strength and durability. The screw bushings are of high-carbon steel and provided with durable bearings and collars for taking up the end thrust of the screws.

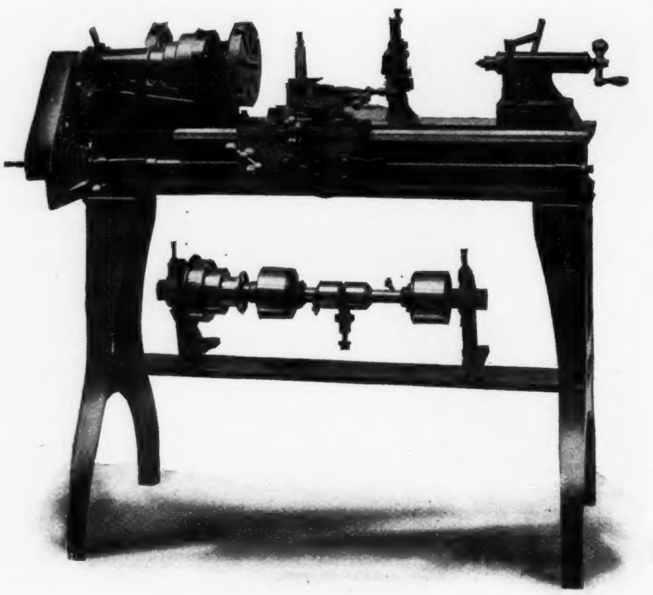
MOLINE THREAD MILLING MACHINE

To meet the requirements of shops that are called upon to cut heavy worms and spirals, the Moline Tool Co., Moline, Ill., has developed what is known as a heavy-duty thread milling machine, which is illustrated and described herewith. In handling work of the kind for which this machine is intended, it is essential to have the machine as rigid as possible, and in working out the design great care was taken to combine the features of heavy construction and simple design. The Moline Tool Co. has had wide experience in handling the class of work done on this machine, and this decided the company in favor of a machine with a traveling table and the cutter held stationary with the exception of providing sufficient traverse to feed the cutter in and out of the work. The majority of operations of this kind are of such a kind that a driving gear can be used on the cutter-arbor which is much larger than the diameter of the cutter, and this is a desirable condition both as regards durability of the cutter and smoothness of the cut. Bearing this in mind, it was decided to use a large driving gear on the cutter-arbor, although this gear can be removed and a small gear substituted when necessary.

The cutter-arbor is hardened and ground and runs in bronze bushings. It is driven through a powerful spur and spiral gear train. The lead-screw is splined its entire length and is made heavy to avoid danger of torsional deflection. The change-gears used on this machine are six pitch. The indexing device consists of a plunger which drops into an indexing plate set into the back of the main spindle driving gear. Work can be held on centers or in a collet chuck, or a three-jaw chuck can be screwed to the spindle nose. A steadyrest block is furnished to which bushings can be fitted for supporting worms on their large diameter or on the shaft, as may be desired. The capacity of the machine is for swinging 8 inches and taking work up to 30 inches in length between centers; the spindle is bored 3 9/16 inches to allow a 3 1/2-inch shaft to pass through it. The regular equipment furnished includes a pump and piping with a tank in the base, a two-speed countershaft, an index plate with any desired number of holes, a bushing for the steadyrest block, and a set of change-gears. The weight of the machine is approximately 5000 pounds.



Thread Milling Machine built by Moline Tool Co.



Sterling 12-inch Back-geared Lathe

STERLING LATHE

The Sterling Machine Tool Co., Paulding Place, Cincinnati, Ohio, is now building the 12-inch back-geared lathe that forms the subject of the following description. This lathe is built with beds of different lengths to provide for taking 24, 36, and 48 inches between centers. Reference to the illustration will show that the machine is of light but compact design, and it is said to be capable of turning work accurate to 0.0015 inch in 18 inches. The lathe has independent longitudinal and power cross-feeds, semi-quick-change gears, a compound rest, and is made to be driven by either foot power, a belt, or individual motor. The regular equipment furnished with the machine includes a compound rest, steadyrest, faceplate, friction countershaft, gear guards, and the necessary wrenches for making all adjustments. Extra attachments that are available for use on the machine include a milling attachment, gear-cutting attachment, turret attachment, and taper attachment.

The principal dimensions of the machine are as follows: swing over bed, 12¼ inches; swing over carriage, 8 inches; diameter of hole through spindle, 1 inch; diameter of spindle nose, 1⅝ inch; size of front and rear spindle bearings, 1 7/16 by 2¼ inches; size of cone pulley, 3, 4½, and 6 inches in diameter by 1½ inch face width; ratio of back-gears, 7 to 1; diameter of tailstock spindle, 1 3/16 inch; diameter of lead-screw, 13/16 inch; threads per inch on lead-screw, 5; travel of tail spindle, 4½ inches; length of carriage on bed, 12 inches; travel of compound rest, 2¼ inches; size of lathe tools, ½ by 1 inch; range for thread cutting, 3 to 120 threads per inch; and diameter of faceplate, 8 inches.

BAUSH STATION TYPE CRANKSHAFT DRILLING MACHINE

For drilling and reaming six holes in the flange of crankshafts, the Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass., has recently designed and built a special form of its station type machine, which is illustrated and described herewith. While the details have been modified to meet the requirements of this work, the general features are similar to preceding types of machines built for other purposes; in the present instance six holes can be drilled and reamed in the flange of a crankshaft in fifty seconds. Fig. 1 shows station No. 1, where the operator loads and unloads the crankshafts. Attention is called to the "start" and "stop" push-button control, which is conveniently located at the operator's right hand. This is an Electric Control & Mfg. Co.'s apparatus, and it governs a five-horsepower Westinghouse motor mounted on top of the machine. Below the electric switch there is a hand-lever for controlling the feeding of the drill heads to the work.

All the bearings in the machine are automatically lubricated,

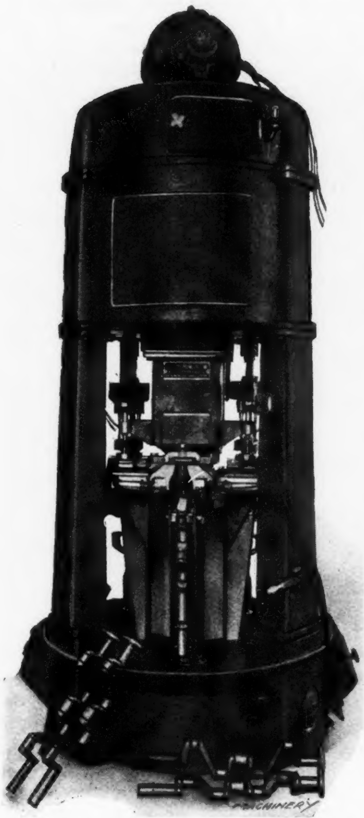


Fig. 1. Baush Station Type Machine for drilling and reaming Six Holes in Crankshaft Flange

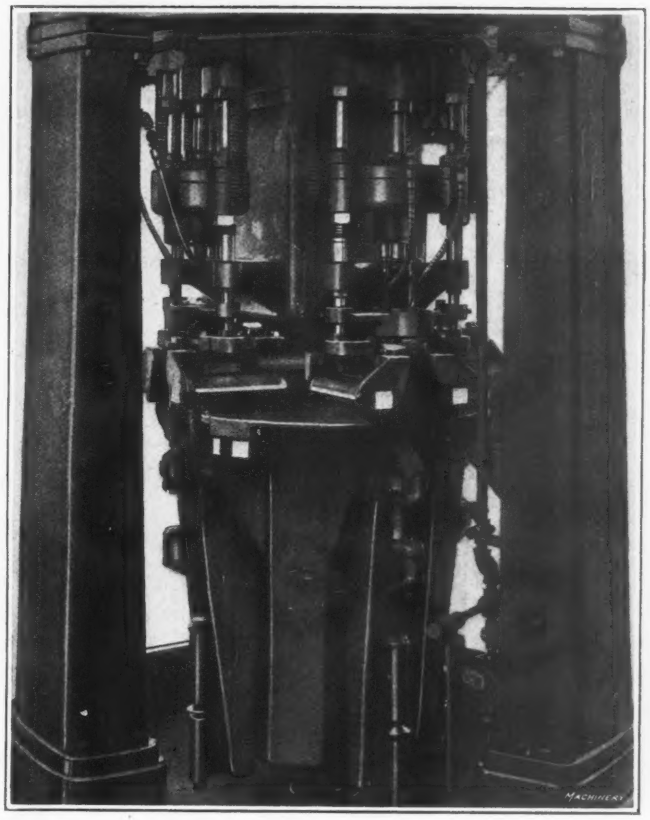


Fig. 2. Close View of Stations Nos. 2 and 3 on Machine shown in Fig. 1

and sight-feed oilers are located where the operator has a clear view of them. Stations Nos. 2 and 3 are shown in Fig. 2, and this close view shows clearly how each crankshaft is supported vertically on centers and held in fixtures which are free to float universally in order to line up correctly with the heads each time the table is indexed. At station No. 2 two pin holes are drilled in the crankshaft flange, and these holes are reamed at station No. 3. Flexible tubes carry cutting oil to the tools, and attention is called to a pump located near the base of one column; this pump is furnished with a relief valve shut-off. There is a fourth station at which the four bolt holes in the flange are drilled. On this machine the 15/32-inch drills are driven at 202.6 revolutions per minute and are fed at 0.0053 inch per revolution. For reaming, 0.441-inch reamers are driven at 74.6 revolutions per minute, and the rate of feed is 0.0138 inch per revolution. The machine is 4 feet in diameter by 10 feet high and weighs approximately 5050 pounds.

LEISY-PATTON SHAPER

The Leisy-Patton Co., Cleveland, Ohio, is now building a shaper which forms the subject of the following description. Taper gibs have been provided throughout to afford means of adjustment. The table support is readily adjusted to suit any elevation, and the cross-rail cavity for the table feed-screw is on an angle which serves to prevent accumulation of chips and dirt. Both the body and base of the machine are ribbed internally to eliminate spring and afford the necessary rigidity. The semi-steel bull gear is run by a bronze pinion, which combination affords the double advantage of strength and durability.

The principal dimensions of this machine are as follows: maximum length of stroke, 20½ inches; horizontal travel of table, 26¼ inches; distance from table to bottom of ram for position of lowest adjustment, 14½ inches; size of vise jaws, 12 inches long by 2½ inches high; maximum opening of vise jaws, 10 inches; width of ram, 10 inches; length of ram, 38½ inches; length of ram bearing on column, 31¼ inches; minimum speed of ram, 8 strokes per minute; maximum speed of ram, 98 strokes per minute; maximum feed, 3/16 inch per stroke; size of table, 18⅜ by 14 inches; length of rocker arm, 31⅝ inches; width of belt, 4 inches; speed of countershaft, 215 revolutions per minute; diameters of four-step cone pulley, from 7¾ to 13 inches, 3 inches face width; number of available speed changes, 8; and floor space occupied by machine, 4 feet, 2 inches by 4 feet, 5 inches.

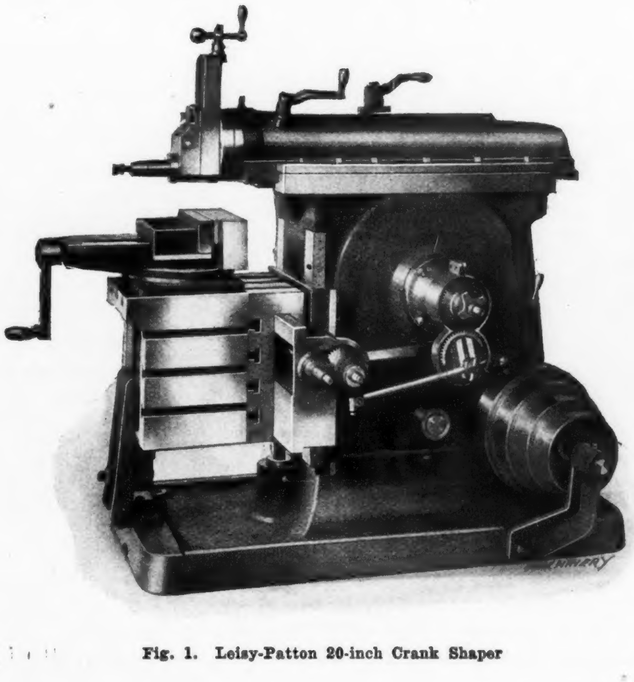


Fig. 1. Leisy-Patton 20-inch Crank Shaper

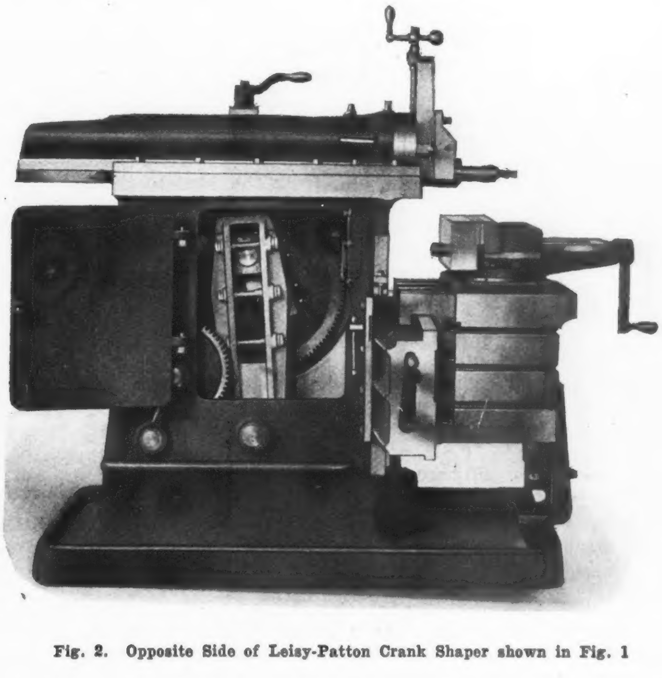
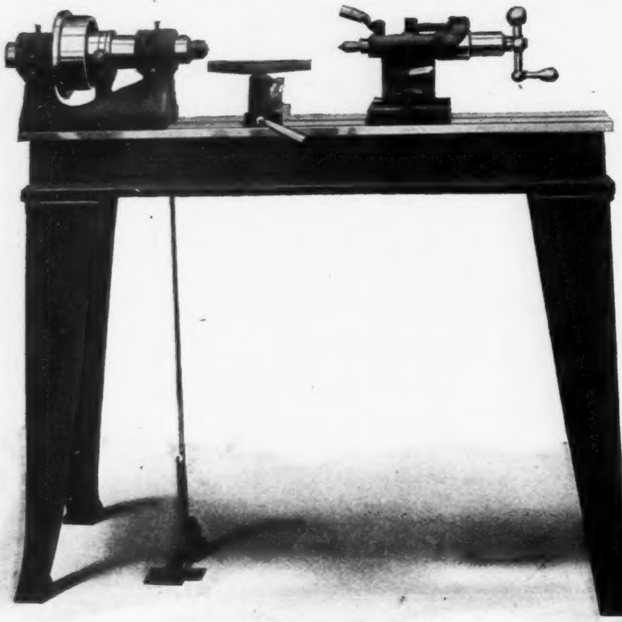


Fig. 2. Opposite Side of Leisy-Patton Crank Shaper shown in Fig. 1

J. G. BLOUNT DRAW-IN FRICTION HEADSTOCK

J. G. Blount Co., Everett, Mass., is now building a friction headstock lathe with a draw-in mechanism, which is illustrated and described herewith. This machine is well adapted for the rapid production of small machine parts. The spindle is provided with a draw-in attachment and is driven by means



J. G. Blount Friction Headstock Lathe with Draw-in Mechanism

of a friction, operated by a foot-treadle. A spring under the sleeve draws the collet back into the spindle and causes it to grip the work, while a forked lever spans the sleeve and is connected to the foot-treadle in such a way that application of pressure opens the collet and instantly stops the spindle. The work can then be removed or put into the collet, and both of the operator's hands are free to handle the work or tools. Self-oiling bronze bushings support the spindle, and the spindle nose is fitted with a hardened bushing to avoid wear while closing the collet; also, the spindle nose is threaded to provide for using a chuck or faceplate. This headstock is also arranged for mounting on a bench, and collets can be used which have a capacity for handling work up to 5/8 inch in diameter.

NEW MACHINERY AND TOOLS NOTES

Polishing and Buffing Lathe: Noble & Westbrook Mfg. Co., Hartford, Conn. It is claimed that as the unbalanced grinding or buffing wheels used on this lathe will automatically find and revolve in their center of gravity, these machines make unnecessary all preliminary balancing of the wheels when setting up.

Bench Drilling Machine: Henry & Wright Mfg. Co., Hartford, Conn. The work may be drilled either on the base or on the swinging table. The maximum distance from the table to the chuck is 3 1/16 inches, and from the base to the spindle, 8 inches. The minimum distance from the base to the spindle is 5 inches. The machine weighs 135 pounds.

Single-purpose 17-inch Lathe: Wickes Bros., Saginaw, Mich. While this machine is intended for fast heavy work, it is not equipped with back-gears or screw-cutting mechanism. It has three feeds, which are operated by the quick-change lever and the spindle has ball thrust bearings for taking up the end thrust. An automatic stop may be provided.

Wire and Metal Former: M. D. Kilmer & Co., Cleveland, Ohio. This former will handle wire from No. 26 to No. 3 gage, with only slight changes in adjustment. With the ten adjustments furnished, it is possible to make a large number of finished forms. Figures on the plate indicate the length of wire to be fed and the angle to which it should be bent.

Grinder for Gear-cutters: Fenn Mfg. Co., 516 Asylum St., Hartford, Conn. The work and the indexing mechanism are mounted on a table that swings on bearings protected from dirt by oil-soaked felt washers. As this table may be raised or lowered on the vertical post, the cutter may be located in the desired position. The motor is attached to a hinged plate beneath the bed and the belt is inside the head.

Hellman Universal Triangle: Charles E. Baker, Indianapolis, Ind. This instrument is a 6-inch, 45-degree, nickel-plated steel triangle, with the hypotenuse in two parts, the larger of which moves on a hinge. The loose end of the hinged section has a groove that fits over a tongue milled to the proper radius on a triangle and may be set to form any angle from 0 to 45 degrees with one side and from 45 to 90 degrees with the other.

Air Compressor: Yokom Sales Co., Port Huron, Mich. The piston of this compressor is driven by a ball-bearing eccentric, the bottom of the piston being held in contact with the outer ring of the bearing by springs. The small compressor, which has a 3-inch bore, has a capacity of 1.8 cubic foot of air per minute, and a power consumption of 1/4 horsepower, while the larger machine delivers 4 cubic feet of air and requires 3/4 horsepower.

Pipe-threading Machine: William T. Johnson Co., Cincinnati, Ohio. This machine is fastened to the section of pipe to be threaded by an expanding sleeve. A standard pipe-thread taper cut on one end of this sleeve serves as a feed-screw. The arm that engages this thread also carries the cutting tool, which is a piece of 3/8-inch square high-speed steel. The operation is repeated a number of times, the tool being advanced a little each time, just as when cutting a thread on a lathe.

Titeflex Metallic Tubing: Titeflex Metal Hose Corporation, 141 Broadway, New York City. Because of the U-shaped sections of this tubing, packing is unnecessary, as there is no sliding of the parts of the joints. It is claimed that the joint becomes tighter with an increase of pressure; that the tubing will carry practically any pressure; and that it is unaffected by heat or cold. For tubing that is to be subjected to rough usage or abnormal exterior wear, a covering of interlocking steel ribbon is provided.

Blueprint Ironer: American Laundry Machinery Co., Cincinnati, Ohio. All types of blueprints, black-line, and Van Dyke prints are ironed and dried by this machine. A fabric apron carries the prints underneath and around a 20-inch cylinder, which may be heated by steam, gas, or electricity. The machine requires 55 cubic feet of gas per hour, 11 kilowatts of electricity, or from 1 1/2 to 2 boiler horsepower of steam at from 6 to 10 pounds pressure. Allowing for delays, it has a capacity of 45 square feet per minute.

Automatic Grinding and Polishing Machine: Kane & Roach, Niagara and Shonnard Sts., Syracuse, N. Y. This machine is designed to grind and polish 1/4- to 5/8-inch tubes and drill rods. In order that there will be no scratches on the finished product, the material is fed in through hardwood tubes. It is then run between hardened tool-steel rolls set at such an angle that the material revolves as it is fed between the polishing belts. The feeding rolls revolve the material between these belts in a direction opposite to the travel of the belts.

Remote Control Switch: Cutler-Hammer Mfg. Co., Milwaukee, Wis. The solenoids that operate this switch, one opening and one closing it, are energized by circuits connected to push-button control switches, which may be placed wherever desired. The contacts are kept closed by a mechanical latch, thus reducing the current consumption. The switches are made with a capacity of 100 amperes for use on either alternating or direct current; they are also made in single-, double-, and triple-pole types. One of their applications is the control of lighting circuits from a distant point or central location.

Motor Headstock for Wood-working Lathes: Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. In this lathe the faceplates, or centers, are mounted directly on the motor shaft, and various speeds are obtained by means of the controller mounted at the front of the lathe. Motor speeds of approximately 570, 1140, and 3460 revolutions per minute are provided with alternating current, and from 600 to 3000 revolutions per minute with direct current. In the latter case, a commutating-pole shunt-wound motor is used. With the alternating current, a dynamic braking effect is obtained by manipulating the controller for the next lower speed.

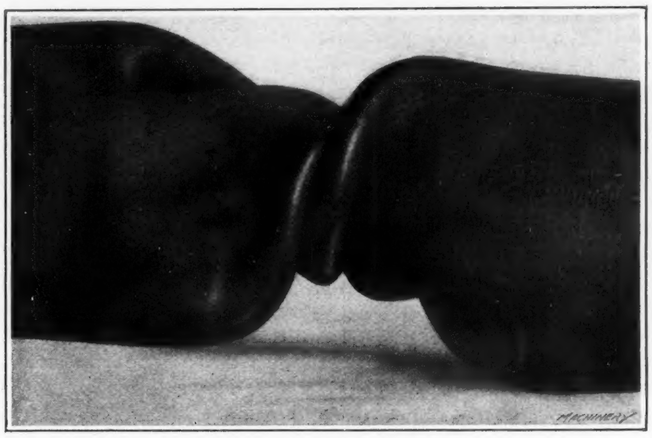
Adjustable Lifting Truck: F. J. Bloodgood Co., Binghamton, N. Y. This truck, which can lift and carry loads from 1000 to 6000 pounds, has a U-shaped frame, the width of which is easily varied, so that the truck can handle loads of any widths. In use, the frame is placed around the object to be carried and the front is raised by means of the screw jack attached to the base of the U at the front of the truck. When the front of the object is raised sufficiently, a bar is passed through the rear wheels, which are placed slightly back of the center of the load; then the jack is lowered, placing the greater part of the weight upon the roller bearing wheels. The frame is not relied upon for support to any extent.

* * *

According to invoices certified at the American consulate general at Rio de Janeiro, Brazil, the exports of manganese ore to the United States increased from 244,946 metric tons, valued at $2,880,107, for 1915, to 496,498 tons, valued at $7,928,869, for 1916.

TORSIONAL TEST OF "NATIONAL" PIPE

The accompanying illustration shows what at first glance might be taken for a twisted sheet of rubber, but instead it is a piece of eight-inch "National" line pipe after having been subjected to a torsional stress of 713,000 inch-pounds and twisted 360 degrees. Eight-inch line pipe weighs about 29



Torsional Test of "National" Line Pipe

pounds per foot, and the wall is approximately one-third inch thick. The test specimen shows the homogeneity, ductility and high tensile strength of the steel.

* * *

ACTIVITIES OF THE S. A. E.

A Washington office has been opened by the Society of Automobile Engineers (hereafter to be known as the Society of Automotive Engineers) in the Munsey Bldg. in connection with the Council of National Defense. This action was taken to bring about closer cooperation of the society with the various government departments. The society has cooperated with the quartermaster's department in drawing specifications of the 1½- and 3-ton military trucks. A great deal of other work remains to be done.

Because of war conditions, the summer meeting scheduled to be held the last week in June at Ottawa Beach, Lake Mich., has been called off. An extensive canvass of many connected with the activities of the society showed a general feeling that few of the members could afford to spend four days at the summer meeting. Instead of four days at Ottawa Beach, it was voted to spend one day on the summer meeting at Washington, D. C.

* * *

LUBRICATION OF CUTTING TOOLS—CORRECTION

It has been brought to our attention that there might possibly be some misunderstanding with reference to the statement in the third paragraph, left-hand column, on page 707 of the April number, in the article "Lubrication of Cutting Tools—4," regarding the investigation on fire hazard of cutting oils. The investigation referred to, which was conducted by Edward A. Barrier, chemical engineer, was undertaken by the Inspection Department of the Associated Factory Mutual Fire Insurance Cos., on their own initiative, as a result of their appreciation of the fact that large quantities of cutting oil as at present used in many machine shops might present a serious fire hazard.

* * *

"CHAMPION" ENGINE LATHE

The "Champion" engine lathe is made by the Champion Tool Works Co., Cincinnati, Ohio. An article in the April number describing the "Lancaster" 13-inch lathe made by the Champion Blower & Forge Co. of Lancaster, Pa., was erroneously headed "Champion Engine Lathe," from which some may have inferred that the lathe made by the company is to be known as "Champion." The article, however, states that the lathe is to be known as the "Lancaster."

NATIONAL METAL TRADES ASSOCIATION'S CONVENTION

The nineteenth annual convention of the National Metal Trades Association was held in New York City, April 23 to 26, inclusive. The convention program proper began Wednesday morning. William H. Van Dervoort, president, delivered a masterly address in which he reviewed the business conditions and pointed to some of the problems that would confront American manufacturers during the war and particularly following the close of the war. F. C. Caldwell, treasurer, in making his report, referred to the difficulties that had been experienced during the past year with labor and labor unions and the drains on the treasury incident to combating strikes and labor hold-ups. The treasury, nevertheless, is in very satisfactory condition, thanks to the generosity of the membership. John D. Hibbard, commissioner, reported on the activities of the association, going into considerable detail as to the work done; and Homer D. Sayre, secretary, also reported on the activities with which the secretary was particularly concerned. Reports of standing committees were made by F. A. Geier, on industrial education; W. A. Viall, on apprenticeship; John W. O'Leary, on membership; and by F. E. McKee, on the prevention of industrial accidents. Unfortunately, Howard E. Coffin, who was scheduled to speak on the activities of the Council of National Defense, was unable to be present because of the emergency with which the country is now confronted. Other papers in the afternoon schedule were:

"The Bankers Cooperation with Industry," by F. C. Schwedtman.

"National Industrial Conference Board," by William H. Barr.

"The American Institute of Weights and Measures—What it Stands for," by Luther D. Burlingame.

The regular convention banquet was held Wednesday evening at the Hotel Astor.

On Thursday morning Wallace Downey delivered an address on the merchant marine, following which were timely addresses by A. L. Humphrey of the Westinghouse Air Brake Co., George F. Steedman of the Curtis & Co. Mfg. Co., and James T. McCleary of the American Iron and Steel Institute.

* * *

WORLD'S GOLD OUTPUT

A century ago, the bulk of the world's gold output, which was $7,300,000 annually, was derived from workings in the Ural Mountains; but as other sources of supply were discovered the production rapidly increased until, in 1916, it amounted to $465,845,700. Forty-seven per cent of this, or $218,973,000, was produced in South Africa, 41 per cent being obtained in the Rand. The total gold output of the British Empire was $292,904,900; $11,193,000 was obtained in India. Until the discovery of the Yukon fields, nearly all the output of Canada was a by-product in connection with copper smelting, and averaged only about $973,000 worth of gold per annum; last year's Canadian output was $19,709,300. While the total output of the American fields, since the first Californian finds in 1847-48, has been approximately $3,397,000,000, the output of the United States last year was $92,643,000. This was about $4,000,000 more than the output in 1913 but about $6,000,000 less than that of 1915.

* * *

UNITED STATES ARMOR PLATE PLANT

The United States armor plate and projectile plate plants for which Congress appropriated $12,700,000 will be built at Charleston, W. Va. The armor plant appropriation was $11,-000,000, and the projectile plant appropriation $1,700,000. The location was chosen as being ideal because of being near large coal deposits and deposits of basic and Bessemer iron ore. Limestone is also quarried in the vicinity. The chief reason, however, for locating the plant near Charleston is the security afforded by being in the Appalachian range many miles from the seacoast, where it is not likely to be seized in an invasion by an enemy.

ELECTRICALLY HEATED PRESSES FOR MOLDING MATERIAL

In industrial service electric heating has many advantages over steam heating which represent an actual saving in money, and in almost every instance the former effects an increase in efficiency that offsets any difference in cost. A step toward the more general application of electric heating in industrial processes has recently been made by the Westinghouse Electric & Mfg. Co. of East Pittsburg, Pa., in the adoption of electric heating for twenty-three presses used in the manufacture of molded composition material. These presses were formerly heated by steam, but a trial electrically heated press proved so satisfactory that the entire set of presses in the company's molded insulation department is now being modified for equipping with electric heaters.

The illustrations show the construction of the machines and the relation of the heaters to the presses. The heat is furnished through two plates, 1 foot square by 3½ inches thick, shielded on their exposed surfaces with magnesia to reduce the radiation losses. The upper plate is stationary and has a hole in it in which a thermometer is inserted to indicate the temperature, as shown in Fig. 1. The lower plate is movable vertically. Each plate is made up of two parts, in each of which there are two grooves. The heating units lie in these grooves, as can be seen in Fig. 2. Thus there are four heating units to each plate, or eight per press. Each unit is 12 inches long by 2¼ inches wide, 3/16 inch thick, and is rated at 300 watts. The heating units are of the Westinghouse steel-clad bayonet type, consisting of a flat ribbon resistor assembled in a mica sheath and enclosed in a heavy steel casing. This construction reduces the possibility of injury to a minimum, and also provides rapid transfer of heat from the resistance element, thus insuring long life under severe conditions of service.

The presses are arranged in sets of four. Current is supplied to each set through a multi-tap transformer and a dial plate. By turning the controller handle on the dial to different positions, varying voltages can be impressed across the heaters. The dial has fifteen contacts and furnishes fifteen voltages, varying from a maximum of 220 volts—the line voltage—to a minimum of 150 volts, with relative inputs for each set of heaters of from 2400 watts maximum to 1200 watts minimum. This arrangement provides for an input of high value for quick heating when the press is cold and it is desired to heat it rapidly; one of low value when the press is not to be used but is to be kept hot for later use; and several intermediate inputs when it is desired to keep the press hot while in steady use on work having different heat requirements.

In the morning the heating plates of the presses, after having been idle during the night, are cold. Before putting a mold into the press, the operator first has to bring the temperature up as quickly as possible. This is accomplished by turning the controller handle to the maximum heat position, the two plates being pressed together to decrease the radiation losses as much as possible. When the proper operating temperature has been reached, the controller handle is turned back to the position experience has shown will maintain the proper temperature for heating the molds. The lower plate is then lowered and the mold to be heated is placed on it, when the lower plate is raised again, with a certain pressure. The press is then left in this position for the length of time required to heat the mold, when the lower plate is again lowered, the hot mold removed, and another cold one put in its place.

During the noon hour, or during periods of rest when the press is not being used but it is desired to keep the plates hot for future use, the controller handle is turned to the position which will supply the radiation losses of the machine, the plates being left together to decrease such losses.

The temperature and the length of time required for one operation depends on the material being heated and the size

Fig. 1. Electrically Heated Presses and Transformer for varying Voltage

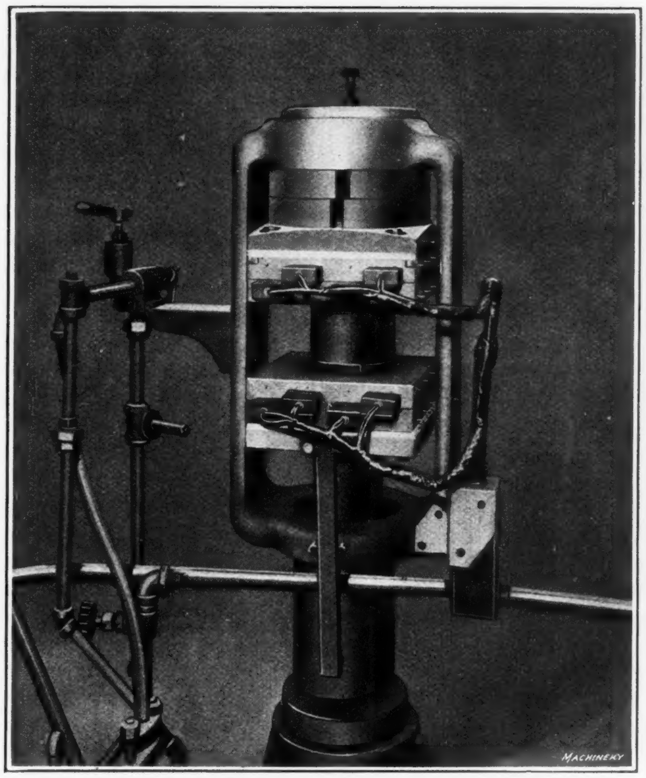


Fig. 2. Close View of Press with Magnesia Covering removed to show Wiring and Heating Units

of the mold. A series of tests made on one of the presses shows that from 1 to 1¼ hour is required to heat the plates of a press, starting with the plates cold, and that 1800 watts are required to keep the press hot while in steady use for work requiring a temperature of 180 degrees C. Should the nature of the material be such that a different temperature is required, or if it is desired to increase or decrease the amount of heat, it is only necessary to turn the controller handle to a position that will give the proper amount of heat necessary.

* * *

THE METRIC SYSTEM IN GREAT BRITAIN

The tremendous change that has taken place in Great Britain during the past three years manifests itself in numerous ways. In the field of engineering, perhaps no indication is more significant than the fact that *Engineering*, in a leading editorial, in the issue of March 30, entitled "The Metric System," takes a friendly view toward the adoption of the metric system in Great Britain and, while retaining its usual well balanced judgment on engineering questions, expresses opinions that can be understood in no other way than as an advocacy of the metric system. This, indeed, would have been unbelievable and unheard of three years ago.

"There are only two systems possible in this country (Great Britain)," says *Engineering*, "our own and the system which is already obligatory with 437,000,000 people and optional with 727,000,000 in other countries. . . . The adoption of the metric system in this country has been largely treated as an academic question in the past. In spite of our system—or want of system—we have been successful, and our exports have risen with satisfactory uniformity. We have made money, we have amassed capital, and we have spent lavishly. But we are now entering upon another phase under quite new conditions. After the proclamation of peace, we shall be faced with greatly increased wages and enormous taxation, and the national income, which was once ample, will no longer suffice. Prices will be high, and although the working classes will be able to spend, the middle classes with fixed incomes will be obliged to curtail their outlay. Under such conditions we must extend our trade abroad by every possible means, and to do so we must copy our rivals—that is, we must take trouble to meet the desires of our customers. The first step toward that end is to count the cost and to compare it with the possible gain, and, if the calculation shows a profit, to go forward. It must be remembered that the cost is not a continuing one. Once the outlay and confusion attending the change have been encountered, they are at an end, while the profit will go on from year to year."

It is further mentioned that since 1840 thirty-four countries have abandoned their original standards and adopted the metric system. Not one country has adopted the British measures, and no country has abandoned the metric system and gone back to its old units. *Engineering*, however, by no means underestimates the difficulties of a change. It recognizes that "in no country was the change so difficult as it will be here, for in none was manufacture so highly organized. We shall have to pay for our footing when we enter the community of metric countries, and the point that waits for settlement is what it will cost us. . . . Our own impression is that the cost will be found to be very much less than many anticipate."

The above statement from *Engineering* is reproduced because of the peculiar interest to American engineers at the present time, when the subject is again being considered in this country, and when two organizations have been founded, one known as the American Institute of Weights and Measures, the object of which is to oppose the metric system, and the other, the American Metric Association, the object of which is to further the adoption of the metric system in the United States. The activities of these two organizations will tend to make the subject more thoroughly understood by engineers in the United States, and in the course of discussions that will take place, much valuable information, both for and against the metric system, will, no doubt, be placed on record. Should Great Britain adopt the metric system, it is evident that the question of its adoption in the United States will become more acute than ever, and the more authoritative and unbiased opinions on the subject that can be placed before American manufacturers and engineers, the more easily will a decision be reached when the time comes that a decision must be reached.

* * *

SPECIAL GEAR-HOBBING MACHINE

When the Phoenix Mfg. Co., Eau Claire, Wis., started to prepare for the manufacture of Conradson engine lathes, difficulty was experienced in making the necessary arrangements for cutting the gears. The shop was not equipped with machines for cutting the gears used in the lathe headstock, carriage, etc., and both builders of gear-cutting machinery and shops engaged in the performance of contract work in gear-cutting were so busy that it was impossible for the Phoenix Mfg. Co. either to buy gear-cutting machinery to cut gears in its own shop or to contract for having the gears cut and obtain reasonably prompt deliveries. When these conditions became apparent, C. M. Conradson decided that the only step open to the company was to build a special machine for doing this work, and the result of his efforts in this direction is the gear-hobbing machine which forms the subject of this article.

In order to facilitate the work of building this machine as far as possible, the design was worked out in such a way that use could be made of one of the bed castings for a Conradson lathe. Those who are familiar with the construction of these lathes will notice that use has also been made of the standard tailstock and parts of the standard carriage. This machine is adapted for hobbing spur and spiral gears and worm-wheels, and to adapt it for handling all these classes of work, mechanism had to be provided to meet the following conditions: In hobbing spur and spiral gears, provision must be made for rotating both the gear blank and the hob, and also for feeding the hob across the face of the gear. For hobbing worm-wheels, similar provision must be made for rotating the work and hob; but instead of feeding the hob across the face of the blank, it must be fed into the work to cut the teeth to the required depth. The means provided for obtaining these results will be explained in detail as the different sections of the mechanism are described. It will be of interest to note that all the work involved in designing and building this machine was completed in six weeks; and using the prices for gear-cutting quoted by jobbing shops as a basis of calculation, the machine paid for itself within the first thirteen days that it was in operation.

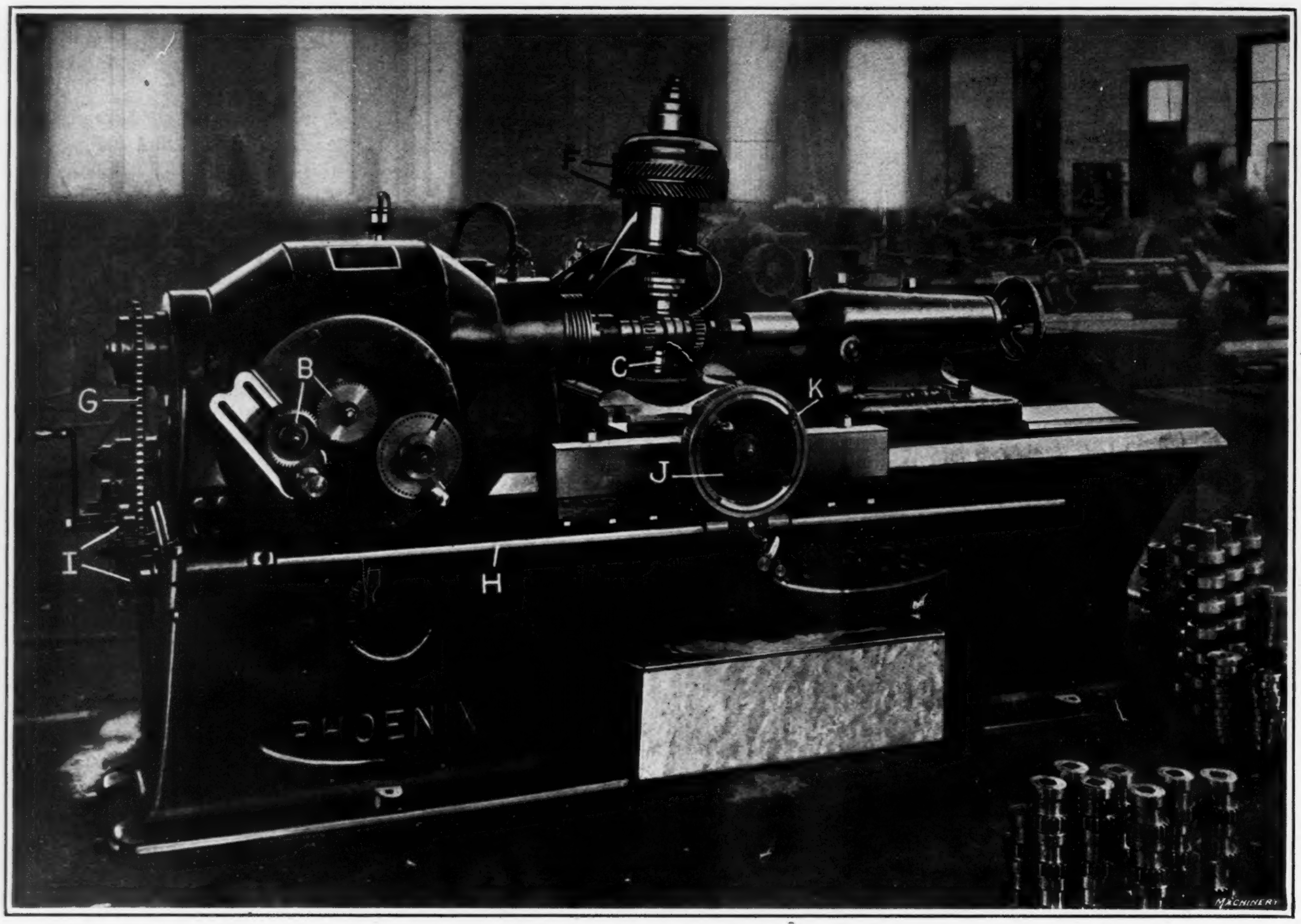


Fig. 1. Special Gear-hobber set up for hobbing Small Spur Gears

In the end view shown in Fig. 2, it will be seen that driving pulley *A* is mounted at the end of a cross-shaft. From this, power is transmitted to change-gears *B*, shown at the front of the headstock in Figs. 1 and 3; and suitable gears can be employed for rotating the gear blank at the desired rate for cutting gears of different sizes. These change-gear ratios have been worked out in such a way that the figuring out of change-gears for cutting the different gears has been simplified as far as possible, making it entirely improbable that the operator will make mistakes. Of course, it is apparent that power is transmitted from gears *B* to the main spindle in the headstock that drives the mandrel on which the gear blank is carried.

The head that carries the hobbing spindle *C* is mounted on the back of the lathe carriage, and in this way it was an easy matter to arrange for longitudinal traverse of this head to provide for feeding the hob across the face of the gear blank. This feed motion is obtained by means of gears *D*, shown at the end of the machine in Figs. 2 and 3, suitable change-gears being provided to enable the rate of feed to be adjusted according to the requirements. It will be noted in these illustrations, however, that the feed motion provided by gears *D* is disengaged; this is because the machine is shown engaged in hobbing a worm-wheel, so that this feed motion is not required. From the change-gears *D*, power is transmitted through a feed-screw to the carriage, provision being made in this way for traversing the carriage along the ways to feed the hob across the face of the gear blank.

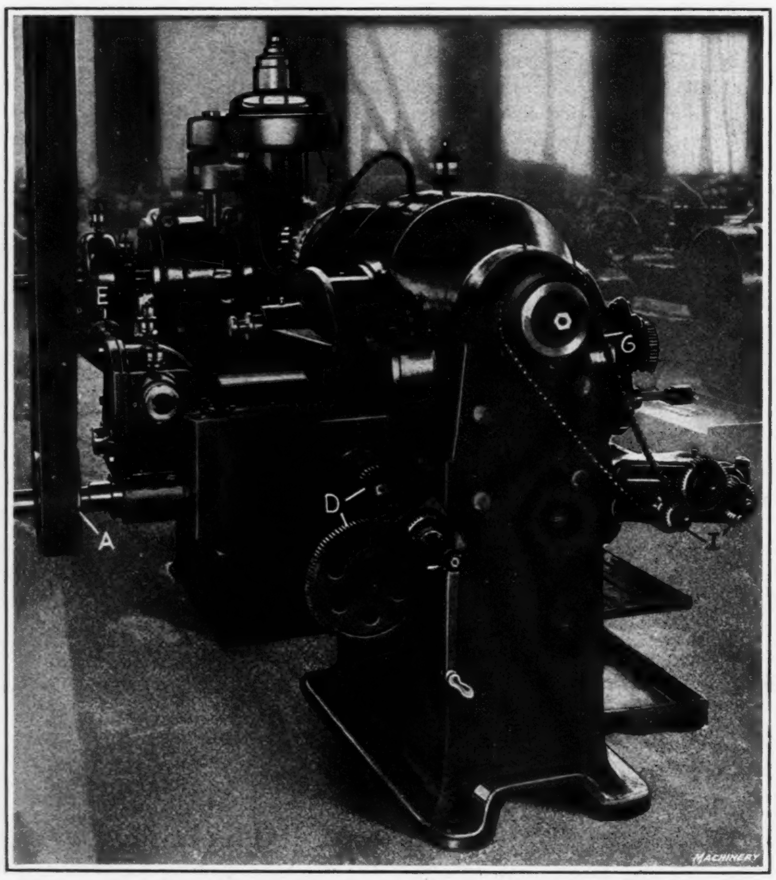


Fig. 2. End View of Machine set up for hobbing Worm-wheels

The drive to the hob is taken through a pair of spiral gears from the main driving shaft that carries pulley *A*, and transmitted through shaft *E*; a second pair of spiral gears and a pair of bevel gears transmit power to the herringbone-gear drive *F* at the top of the head that carries the hobbing spindle. The arrangement of this herringbone-gear drive will best be understood by reference to Fig. 1, in which the cover has been removed in order to show it more clearly. In hobbing spur gears, the hob rotates in uni-

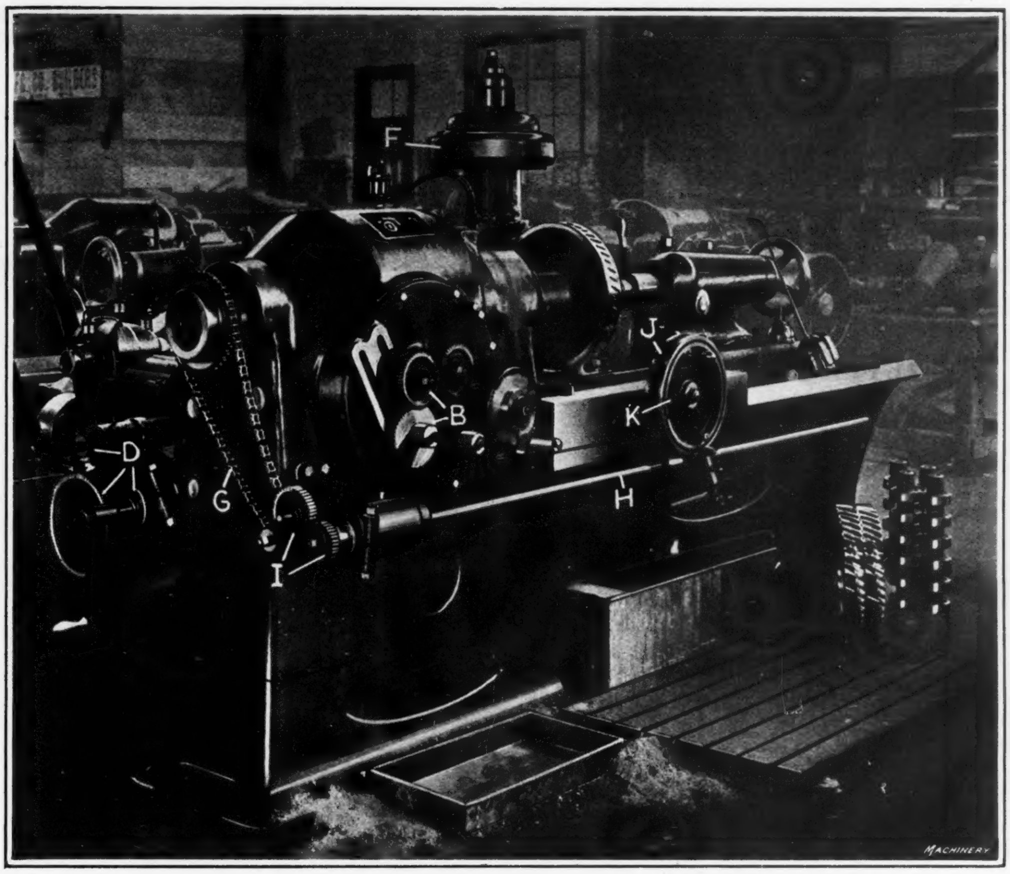


Fig. 3. Machine shown in Fig. 1 set up for hobbing Worm-wheels

son with the gear blank while the hob is fed across the face of the gear. This is not the case in hobbing spiral gears, because it is necessary to cut the teeth to the required spiral angle, and this result is obtained by having a differential motion between the speed of rotation of the hob and the speed at which the gear blank is rotated. To obtain this, change-gears *B* are selected in such a way that this drive and the gearing used for transmitting motion from driving pulley *A* to the hobbing spindle, will give the required ratio between the speeds of the hob and the gear blank. In this way, a suitable differential movement is obtained so that the gear blank will gain on the hob, which results in cutting the teeth to the required spiral angle instead of straight. There is a swivel in the head which carries the hobbing spindle, to provide for setting the hob at the desired angle when hobbing spiral gears. A similar angular setting is sometimes made in hobbing spur gears to compensate for the lead of the hob.

For hobbing worm-wheels, it is necessary to feed the hob into the work, instead of traversing it across the face of the gear blank. On the machine under discussion, this is accomplished by means of the lathe cross-slide which supports the gear-hobbing head. From the headstock spindle a chain drive *G* transmits power to a rod *H* that runs along the front of the machine. At the end of this rod are placed change-gears *I* which provide for regulating the rate of cross-feed; and mounted at the end of the cross-feed screw there is a worm-wheel *J* which meshes with a worm on the horizontal feed-rod *H*. This worm-wheel is furnished with a loose center that carries an adjustable stop *K*; and by setting the loose center and stop in the desired positions, provision is made for tripping the cross-feed when the teeth in the worm-wheel have been hobbed to the required depth. The loose center of the worm-wheel has a micrometer dial graduated on its circumference, and stop *K* is set at the zero mark on this scale. The scale is then run around and set in the desired position opposite an index mark on the rim of wheel *J* so that the cross-feed will be tripped at the desired point. The operation of this mechanism is sufficiently accurate to enable the feed to be disengaged for hobbing gear teeth with a limit of accuracy of 0.008 inch. An idea of the rate of production obtained from this machine will be gathered from the accompanying table, which shows results with spur and spiral gears and worm-wheels of different materials. E. K. H.

RATES OF PRODUCTION OBTAINED ON SPECIAL GEAR-HOBBER

Type of Gear	Material	No. of Teeth	Pitch	Face Width	Lead or Spiral Angle	Production, Gears per Hour
Spur	Cast iron	56	8	1		8
Spur	Carbon steel	25	6/8	1		4
Spiral	Aluminum bronze	27	3	2½	45°	2¾[1]
Spiral	Cast iron	27	4½	1¾	45°	1
Worm	Semi-steel	40	0.4	1½	0.8"	7½
Worm	Semi-steel	44	0.3	1⅜	0.6"	10
Worm	Aluminum bronze	51	1" c. p.	2½	5"	1
Worm	Cast iron	51	¾	1¾	3¾"	2¼

Machinery

[1] One gear completed in 2¾ hours.

* * *

The Panama Canal will have an important rival, it is claimed, in the Uyuni-Tupiza Railway, which will connect La Paz, Bolivia and Buenos Aires. When completed, this route will make it possible to travel from one coast to the other in two or three days less than is now required by the Trans-Andine route, and when in the winter the latter route is closed and the mails must be sent through the Straits of Magellan, ten days will be saved. This railway is also said to be a quicker and more direct transportation route from Europe to the west coast of South America than the Panama Canal, and it is expected that it will be used to a great extent by European exporters.

* * *

FRANK A. SCOTT, CHAIRMAN MUNITIONS BOARD

Frank A. Scott, recently elected chairman of the General Munitions Board of the Council for National Defense, is exceptionally well qualified for that position on account of his wide experience in organization and his familiarity with mechanical work in the executive capacities which he has filled during his business experience. Mr. Scott was born in Cleveland in 1873 and has been a resident of that city all his life. He has always been interested in civic problems and for twenty years has been closely associated with many of Cleveland's activities. As secretary of the Cleveland Chamber of Commerce for ten years, he was associated with numerous public enterprises, and later was connected with one of Cleveland's foremost banking institutions. It was while in the banking business that Mr. Scott was appointed receiver of the Municipal Traction Co., where he made a wide reputation for executive ability. In 1909 he was called to become secretary of the Warner & Swasey Co., of which he is now vice-president and general manager. Mr. Scott has traveled extensively in England, France, Germany and Russia, and his familiarity with conditions in those countries forms a part of his fund of practical information which al-

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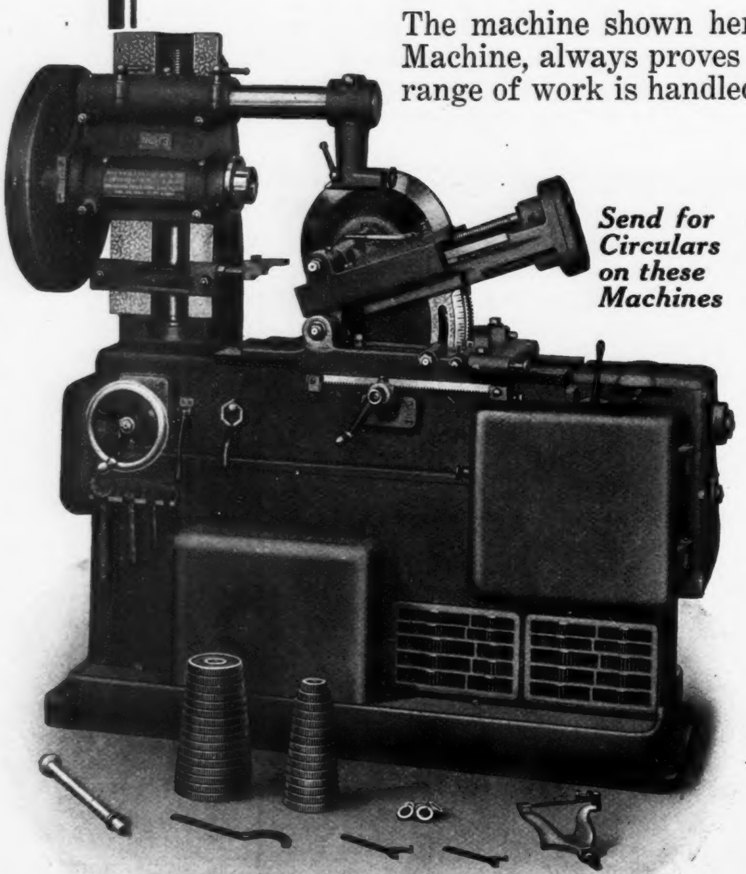
because they produce accurate gears, at a rate that meets the present abnormal demand for fast production. Constant speed drive with high belt contact gives powerful driving action. Ample rigidity permits rapid, heavy cuts to be taken. Independently driven indexing mechanism assures rapid indexing under all conditions. Full control from front of machine allows quick setting up and rapid production.

The machine shown here, our No. 13 Automatic Gear Cutting Machine, always proves a good investment in shops where a wide range of work is handled. On this machine



Send for Circulars on these Machines

You Can Cut Spur and Bevel Gears, Sprockets and Clutches

and maintain accuracy and fast production on all. Let us tell you more about our entire line of gear cutting machines, all of which are

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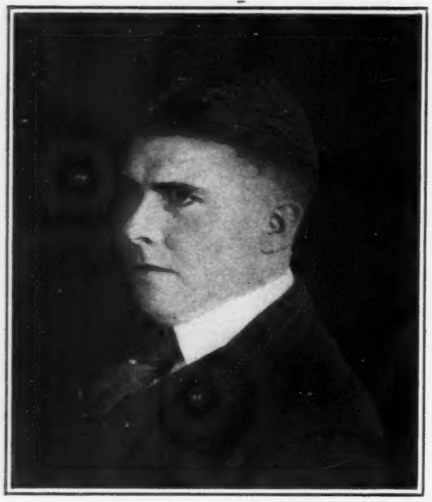

Frank A. Scott, Chairman of Munitions Board

together constitutes an equipment of exceptional value for the important position to which he has been called.

The General Munitions Board will be charged with supplying the army and navy with munitions and equipment, and will pass on the country's military and industrial requirements. The work of the Board corresponds to that undertaken by the British Ministry of Munitions, and it comprises twenty men, fifteen of them army or navy officers, as well as a number of civilians. Besides Mr. Scott, its civilian members are Bernard M. Baruch, Howard E. Coffin, Julius Rosenwald and Dr. Franklin Martin.

PERSONALS

Richard Klaw, Jr., has been appointed advertising manager of the Pawling & Harnischfeger Co., Milwaukee, Wis.

W. Burr Bennett has been made chief engineer and general manager of the Wayne Engineering Co., Honesdale, Pa.

S. H. Reck, general manager of the Greaves-Klusman Co., Cincinnati, Ohio, builder of engine lathes, has resigned.

Charles V. Bacon, consulting and analytical chemist, has moved his offices and laboratory to 3 Park Row, New York City.

C. H. Roberts, formerly factory accountant of the Hess-Bright Mfg. Co., Philadelphia, Pa., has been appointed comptroller.

H. P. Eilers, formerly with Manning, Maxwell & Moore, Inc., has opened an office in the Singer Bldg., New York City, where he will handle machine tools for domestic and export trade.

R. M. Bateson, formerly New York City representative of the W. F. Davis Machine Tool Co., Rochester, N. Y., has made arrangements to represent Ogden R. Adams, machinery merchant of Rochester.

Norman Bell, formerly sales engineer in the automobile division of the Lunkenheimer Co., Cincinnati, Ohio, has joined the Norma Co. of America, New York City, as sales engineer of "Norma" ball bearings.

John H. Marlotte, for many years prominently identified with the machine tool business in the Detroit district, has become connected with the J. R. Stone Tool & Supply Co. of Detroit; he will manage the machine tool department.

W. J. Hill, formerly superintendent of the Embury Mfg. Co., Warsaw, N. Y., and lately with the T. H. Symington Co., Rochester, N. Y., has taken a position as representative of Ogden R. Adams, dealer in machinery and equipment, Rochester.

Zenas W. Carter, Boston, Mass., has been appointed commissioner to supervise publicity, promotion and investigation for the Associated Metal Lath Manufacturers, whose offices have been moved from Chicago to Cleveland, Ohio, Room 901, Swetland Bldg.

Eugene R. Seiter, machine tool designer for five years with the Cleveland Automatic Machine Co., and later with the Warner & Swasey Co., both of Cleveland, Ohio, has resigned from the latter company and joined the Foster Machine Co., Elkhart, Ind., as sales engineer.

H. A. Howard, for many years connected with the C. & C. Electric Co., Garwood, N. J., and until recently associated with the Deihl Mfg. Co., has been appointed manager of the New England office of the C. & C. Electric & Mfg. Co. Mr. Howard has had a wide experience in the electrical line over a quarter of a century.

W. F. Schaphorst, mechanical engineer and advertising expert, and a frequent contributor to the technical press, has established an engineering advertising service office in the Woolworth Bldg., New York City. Mr. Schaphorst will specialize in advertising service for manufacturers of high-grade engineering products.

Maxwell C. Maxwell, formerly superintendent of power and plant of the machine tool department of the Yale & Towne Mfg. Co., Stamford, Conn., has been appointed general superintendent. A. O. Blackman has been appointed superintendent of power and plant, and J. B. Freysinger has been made superintendent of the tool and machine department.

Prof. C. R. Richards, professor of mechanical engineering and head of the department since 1911, has been appointed dean of the College of Engineering and director of the Engineering Experiment Station of the University of Illinois, to succeed Dr. W. F. M. Goss, who resigned to become president of the Railway Car Manufacturers' Association of New York.

George Schow has made arrangements to take charge of the interests of the Export Service & Industrial Corporation, having offices in the First National Bank Bldg., Chicago, Ill. Mr. Schow has been elected a director of the corporation, and will look after its activities in Norway, Sweden, Denmark, Holland, Russia and Siberia. He will continue to cooperate as before with the Northern Engineering & Trading Co. of Christiania, Norway.

Dr. Robert Grimshaw of New York City, an engineer of broad experience in this country and in Europe, will sail for South America early in June as a special agent representing the Bureau of Foreign and Domestic Commerce, to study the markets in Brazil for metal-working and wood-working machinery and for prime movers. Firms desiring to get in touch with Dr. Grimshaw may address him at Room 409, Custom House, New York City.

Fred. A. Geier, president of the Cincinnati Milling Machine Co., Cincinnati, Ohio, and a former trustee of the University of Cincinnati, has made a gift of $25,000 to the university, which will be known as the Frederick A. Geier Students' Loan Fund. The annual interest is to be used to provide loans to students of the cooperative engineering course who need financial assistance. The Cincinnati Milling Machine Co. reserves the right for the first twenty-five years to recommend students eligible for assistance, and the faculty of the college shall have the right to determine the eligibility of students in this department of the university who work two weeks in the factories and study two weeks at the university.

OBITUARIES

James B. Brady, a well-known salesman of machinery and railway supplies, director of Manning, Maxwell & Moore, vice-president of the Standard Steel Car Co., president of the Independent Pneumatic Tool Co., and an officer of other manufacturing concerns, died at Atlantic City, April 13, of heart trouble, aged sixty-two years. He was familiarly known as "Diamond Jim" because of his fondness for jewels, but although a well-known man about town, he was an able salesman and keen business man.

Hiram J. Grover, sales manager of the small tools department of the Brown & Sharpe Mfg. Co., Providence, R. I., died March 29, aged forty-two years. Mr. Grover was born in St. Louis, Mo., and after attending Washington University, he was employed by the Sumter Telephone Co. for a few years. During this time he married Miss Susan Ziegler of Sumter, S. C., who died a year ago. He entered the employ of the Brown & Sharpe Mfg. Co. in January, 1904, and in May, 1905, was made sales manager of the small tools department in which position he continued until the time of his death. Mr. Grover was a man who combined with natural ability and quickness of thought a personality that won for him a large number of friends in and outside his business circles. He leaves a son.

COMING EVENTS

May 8—Annual meeting of the Society for Electrical Development, Inc., at the United Engineering Societies Bldg., New York City. J. M. Wakeman, general manager, United Engineering Societies Bldg., New York City.

May 14-15—Meeting of the American Gear Manufacturers' Association at Pittsburg, Pa. F. D. Hamlin, secretary, Earle Gear & Machine Co., Philadelphia, Pa.

May 14-16—Annual meeting of the National Association of Manufacturers at the Waldorf-Astoria Hotel, New York City. George S. Boudinot, secretary, 30 Church St., New York City.

May 21-22—Spring convention of the National Machine Tool Builders' Association in Cincinnati, Ohio. Charles E. Hildreth, general manager, Worcester, Mass.

May 21-24—Spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio. Calvin W. Rice, secretary, 29 W. 39th St., New York City.

May 31—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

June 11-14—Spring meeting of the Electric Power Club at Hot Springs, Va.; Homestead Hotel, headquarters. C. H. Roth, secretary, 1410 W. Adams St., Chicago, Ill.

June 13-15—Annual convention American Railway Master Mechanics' Association at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

June 13-20—Annual meeting of the Railway Supply Manufacturers' Association at Atlantic City, N. J., in connection with A. R. M. M. and M. C. B. Associations' conventions. J. D. Conway, secretary and treasurer, 2136 Oliver Bldg., Pittsburg, Pa.

June 18-20—Master Car Builders' Association's convention at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

June 23-30—Industrial exposition and export conference at Springfield, Mass. John C. Simpson, general manager.

June 25—Summer meeting of the Society of Automobile Engineers at Washington, D. C. Coker F. Clarkson, secretary, 29 W. 39th St., New York City.

August 30-September 1—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill.; Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

September 10-15—Annual convention of the National Safety Council, New York City; Hotel Astor, headquarters. Marcus A. Dow, president, Grand Central Station, New York City.

September 10-15—Exposition of safety appliances at the Grand Central Palace, New York City, under the auspices of the American Museum of Safety, 18 W. 24th St., New York City. Arthur H. Young, director.

SOCIETIES, SCHOOLS AND COLLEGES

University of Wisconsin, Madison, Wis. Preliminary announcement of the summer session, which extends from June 25 to August 3, inclusive.

Columbia University, Morningside Heights, New York City. Bulletin containing announcement of the summer session day and evening courses. The summer session begins July 9 and continues through August 17.

American Institute of Weights and Measures, 20 Vesey St., New York City, has issued bulletins 1 and 2 on the metric system. The first is known as "The Six Metric Myths," and the second, "Endorsements That Count." Copies are sent free to any address. Other bulletins will follow in season.

Municipal School of Technology, Manchester, England. Journal containing a record of the investigations undertaken by members of the school during the year 1914. The articles contained are as follows: Energy Distribution for Natural Radiation; Slow Reversals of Stress and the Endurance of Steel; Experiments with Lathe Finishing Tools; Prevention or Abatement of Smoke; Training of Sanitary Engineers; Action of Strong Nitric Acid on Cotton Cellulose; Dilution Limits of Inflammability of Gaseous Mixtures; Ignition of Gaseous Mixtures by Electric Discharge; History of Dyeing; Catalytic Acceleration of Vulcanizing Process; Industrial Gas Burning; Action of Sulphuretted Hydrogen upon Hydrosulphites; Determination of Carbon Monoxide in Air; Strength and Wearing Qualities of Cloth; Null Method of Testing Vibration Galvanometers; and Commutation of C.C. Generators and Rotary Converters.

NEW BOOKS AND PAMPHLETS

Court Decisions on Workmen's Compensation Law, July 1, 1914, to August 1, 1916. Special bulletin 81 of the Department of Labor, New York, issued under the direction of the Industrial Commission.

Fatal Accidents Due to Falls in Building Work, Their Frequency, Causes and Prevention. Special bulletin 80 of the Department of Labor, New York, issued under the direction of the Industrial Commission.

The Personal Relation in Industry. By John D. Rockefeller, Jr. Published by John D. Rockefeller, Jr., 26 Broadway, New York City. Reprint of an address delivered at Cornell University, January 11, 1917, dealing with the relations between employers and employes.

How to Run an Automobile. By Victor W. Page. 178 pages, 5 by 7½ inches; 72 illustrations. Published by the Norman W. Henley Publishing Co., New York City. Price, $1.

This book is a non-technical compilation of the operating instructions furnished by motor car manufacturers for car users. It contains, in addition, many practical hints based on the observation and experience of the writer. The work is of interest not only to motor car users, but also to students of mechanism, as it shows a variety of details of modern motor car design.

Oxy-acetylene Welding and Cutting. By P. F. Willis. 180 pages, 4 by 6 inches; 52 illustrations. Published by the author, St. Louis, Mo. Price, 50 cents.

This little book was written in the light of ten years' experience of the author as the proprietor of a welding shop using the oxy-acetylene process, and should be useful to operators of oxy-acetylene apparatus generally. It treats of acetylene, oxygen, the welding and cutting torch, the apparatus and its installation, preparing for welding, welding of different materials, welding of sheet metal and pipe, and welding of miscellaneous pieces. The first portion of the book is presented in the catechism style, after which the matter appears in the usual descriptive style.

The Theory of Machines. By Robert W. Angus. 340 pages, 6 by 9 inches; 193 illustrations. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $3.

This work is in two parts, part one being the principles of mechanism and part two the elementary mechanics of machinery. It is the second edition of a work published several years ago, but rewritten and revised throughout, making it practically a new book. Questions at the end of each chapter have been added, and the phorograph of Professor Rosebrugh has been introduced. The contents of the work by chapter heads follow: The Nature of the Machine; Motion in Machines; Velocity Diagrams; The Motion Diagram; Toothed Gearing; Bevel and Spiral Gearing; Trains of Gearing; Cams; Forces Acting in Machines; Crank Effort and Turning Moment Diagrams; The Efficiency of Machines; Governors; Speed Fluctuations in Machinery; The Proper Weight of Flywheels; Accelerations in Machinery and Their Effects; Balancing of Machinery. The chapter on balancing is new.

Compressed Air for the Metal Worker. By Charles A. Hirschberg. 321 pages, 5½ by 8 inches; 294 illustrations. Published by the Clark Book Co., Inc., New York City. Price, $3.

The aim of the author in writing this book was to explain in a practical way how compressed air is used to advantage in the metal-working field, having been impressed with the dearth of information in published form relating to industrial uses of compressed air. The book is intended for shop owners, superintendents, foremen and machinists, and is offered to mechanical engineering students as a supplement to theoretical text-books. It treats of the compressed air power plant; air compressor details; air compressor accessories; installation and care of air compressors, accessories and air pipe lines; portable pneumatic tools; care and operation of pneumatic tools; compressed air uses in the power plants; compressed air uses in foundries; sandblasting; compressed air uses in the machine shop; compressed air uses in the forge shop; compressed air uses in boiler shops and structural steel plants; the uses of compressed air for hoisting, handling, conveying; cleaning with compressed air; the application of paint, lacquer, enamel, metal coating, etc., by compressed air; pumping with compressed air.

Preliminary Mathematics. By Professor F. E. Austin. 173 pages, 4¾ by 7½ inches. Published by the author, Hanover, N. H. Price, $1.20.

This book is uniform in style with the author's previous publications reviewed in MACHINERY, but is intended especially for those who lack the fundamental training in mathematics necessary for understanding engineering literature in general. The work, we believe, is well within the comprehension of any man able to read and perform ordinary arithmetical calculations. A study of the book from cover to cover should result in giving the average person such a grasp of the fundamentals of mathematics as to enable him to read intelligently the ordinary works on mechanics, electricity, etc. The arrangement of the matter is as follows: quantity, measurement, number, symbols of number and notation, use of letters in mathematics, algebraic symbols, symbols of operation, decimals, multiplication of positive and negative numbers, negative exponents, algebraic expressions, ratio and proportion, solution of equations, constants and variables, logarithms and their general properties, linear equations, quadratic equations, arithmetical progression, geometrical progression. The principles are illustrated with many examples given for practice.

Steam Turbines. By William J. Goudie. 519 pages, 5½ by 8½ inches; 230 illustrations. Published by Longmans, Green & Co., New York City. Price, $4 net.

The work was written to suit the requirements of engineering students, but the methods of calculation outlined should be found useful by engineers in general who have to deal with the design or operation of steam turbines. Numerous examples have been introduced throughout the text. The data in most cases were selected in conformity with practical requirements. The subject matter follows: Classification of Steam Turbines; Impulse Turbines; Reaction Turbines; Combination Turbines; Properties of Steam; Entropy Diagrams; Nozzles; Blading; Rotors; Mechanical Losses and Their Prevention; Condition Curve—Reheat Factor—Internal Efficiency and Efficiency Ratio; Steam Consumption; Provisional Determination of General Proportions of Compound Turbines—Impulse Turbines; Provisional Determination of General Proportions of Compound Turbines—Axial Flow Reaction (Parsons) and Combination Turbines; Provisional Determination of General Proportions of Compound Turbines—Radial Flow Reaction Turbine (Ljungstrom Type); Governing; Steam Tables; Mathematical Tables. The development of steam turbine practice during the past ten years has been so rapid that it has been difficult for engineering literature to keep abreast, but the author has given in this work an able and up-to-date treatise of a comparatively new branch.

Practical Marine Engineering. By C. W. Dyson. 982 pages, 6 by 9 inches; 550 illustrations. Published by "Marine Engineering," New York City. Price, $6 net.

The first edition of this work, published in 1901, was written by Prof. W. F. Durand, at that time head of the department of naval architecture and marine engineering, Cornell University. The book has since appeared in three editions; the fourth edition has been thoroughly revised and entirely rewritten by Capt. C. W. Dyson of the Bureau of Steam Engineering, U. S. Navy Department. The work contains fifteen chapters with the following heads: Principal Materials of Engineering Construction; Fuels; Boilers; Oil Fuel Burning; Marine Engines; Description of the Principal Parts of Marine Engines; Auxiliaries; Valves and Valve Gears; Refrigeration; Electricity on Shipboard; Propulsion and Powering; Operation, Management and Repair; Steam Engine Indicators, Indicator Cards and Torsion Meters; Special Topics and Problems; Computations for Engineers. Many miscellaneous problems and questions with page references to the part of the book where the answers to each question may be found, make the work invaluable to candidates for marine engineers' licenses. In fact, the book has been arranged throughout with the view of making it of greatest value to this class. It is, however, a work that any marine engineer should find acceptable for his library.

The Founder's Manual. By David W. Payne. 676 pages, 4½ by 8 inches; 245 illustrations. Published by D. Van Nostrand Co., New York City. Price, $4.

This is a handbook especially intended for the foundryman, containing, in addition, a great deal of material of a general character. The information has been drawn from many sources, especially the proceedings of the American Foundrymen's Association, "The Foundry," "Castings" and "Iron Age"; a number of MACHINERY's data sheets have also been reproduced. In the selection of the material, the author states that proper consideration has been given to beginners and others whose knowledge of foundry practice is limited. The first 240 pages of the book are made up of general information, such as is found in handbooks generally, on elementary mathematics; weights and measures; natural sines and tangents; tables of wire, sheet metal, pipe and machine details; mechanics; alloys; belting; and other miscellaneous information. Then follows a section covering somewhat over 400 pages devoted specifically to the iron and steel foundry, treating of pig iron, cast iron, mixing iron, test-bars, chemical analysis, standard specifications, malleable iron, steel castings, foundry fuels, cupolas, sand, cores, molding machines, and foundry cost accounts. The book is well printed and nicely bound in flexible leather, but its make-up gives evidence of lack of editorial experience, many pages being only half filled with material, and the arrangement generally leaving much to be desired. This, however, does not materially detract from the value of the book for reference purposes.

Gisholt Turret Lathe Guide—Care and Tooling. 254 pages, 6 by 9 inches; profusely illustrated. Published by the Gisholt Machine Co., 1205 E. Washington Ave., Madison, Wis., for distribution among Gisholt lathe owners and operators.

This book, though a publication issued in the interests of machine tool building concerns, is a valuable treatise on a specialized form of machine tool and specialized machining practice, which should interest mechanics generally. Tooling, which is an almost inexhaustible subject, is treated at length. The section contains many illustrations of standard and special tools for rough- and finish-turning, facing, boring and reaming, giving proper allowances between rough and finish cuts, so as to maintain uniformity of sizes and quality of finish. The uses and advantages of the Gisholt turret lathe are briefly given in the introductory matter, following which are instructions on the care and operation of machines; standard tool equipment; setting of tools; chucking; boring and fitting jaws; chuck jaws, with many illustrations of special forms; centering and supporting spiders; steadyrests; toolpost and toolpost tools; tool grinding, with chart of standard shapes and illustrations of many special shapes; uses of taper attachment; turret tools, including drills and boring-bars, with numerous illustrations; reamers, showing construction and special forms; and facing heads, with examples of common and special forms. Thread cutting and feed changes on the Gisholt machines are described, and details for changing gears are given. The machining of heavy pieces receives attention, and then follow lay-out instructions and time study sheets, of which several examples are given. List of parts with illustrations for ordering conclude the book.

NEW CATALOGUES AND CIRCULARS

General Electric Co., Schenectady, N. Y. Bulletin 40400 A, descriptive of belt-driven alternators, Form PB.

Brown Hoisting Machinery Co., Cleveland, Ohio. Catalogue P, illustrating the line of "Brownhoist" overhead hand traveling cranes.

Arthur Colton Co., Detroit, Mich. Catalogue of "Colton-Detroit" hammered high-speed twist drills with over-size tangs and wide flutes.

Foster Machine Co., Elkhart, Ind. Catalogue of the Foster No. IB universal turret lathe with tools and attachments. This machine can be used either for bar or chucking work.

Gisholt Machine Co., 1205 E. Washington Ave., Madison, Wis. Pamphlet reproducing advertisements of the Gisholt machines that have appeared in the "American Machinist."

Fulton Machine Tool Co., 1438 Bryan Place, Chicago, Ill. Bulletin of the Fulton heavy-duty manufacturing lathe, 18¼-inch swing, 7-foot bed, with plain headstock and friction headstock.

Permanent Products Co., 1020 Engineers Bldg., Cleveland, Ohio. Circular and catalogue of "Permanent" nut locks, showing construction of various types of nut locks, including "Permanent."

National Tube Co., Pittsburg, Pa. Bulletin 27, entitled "Uses of National Pipe," showing the wide variety of uses of National pipe and giving tables of information concerning its physical properties.

Moccasin Bushing Co., Chattanooga, Tenn. Catalogue of "Moccasin" self-oiling bronze bushings for loose pulleys, sheaves and general purpose bearings that are required to run a long time without attention.

Nutter & Barnes Co., Hinsdale, N. H. Catalogue of cutting-off machines and saw sharpeners, containing a detailed description of these machines and illustrating the 4-, 6-, 8- and 10-inch cutting-off machines.

McCrosky Reamer Co., Meadville, Pa. Catalogue 5, illustrating and giving specifications for McCrosky adjustable reamers, "Wizard" quick-change chucks and collets, F.P.M. turret tool-holder, and "Searchlight" universal lamp brackets.

Standard Machinery Co., Auburn, R. I. Sixty-two-page catalogue covering this company's line of plain and automatic drop-hammers. The catalogue also shows the new patented safety device for use in connection with these drop-hammers.

Rivett Lathe & Grinder Co., Brighton District, Boston, Mass. Catalogue of the Rivett line of lathes and grinding machines, comprising precision bench lathes, back-geared precision lathes, precision turret lathes, lathe attachments, internal grinders, Rivett thread tools, chucks, etc.

National Tube Co., Pittsburg, Pa. Reprint of a paper entitled "A Method for Practical Elimination of Corrosion in Hot Water Supply Pipe," presented by F. N. Speller, metallurgical engineer with the National Tube Co., before the American Society of Heating and Ventilating Engineers.

Spray Engineering Co., 93 Federal St., Boston, Mass. Bulletin 501, entitled "Spraco Products," illustrating and describing the various lines made by the company, which include air washing and cooling equipment, paint spraying equipment, sprinklers, flow meters and nozzles.

Fitchburg Machine Works, Fitchburg, Mass. Catalogue of the "Radical" automatic, in loose-leaf form, with details of construction, countershaft and floor plans, lists of parts, etc. The catalogue has been compiled with a view to making the construction and operation clearly understood by the average user.

National Lamp Works of General Electric Co., Nela Park, Cleveland, Ohio. Bulletin 30, on "Protective Lighting for Industrial Plants," which is published as a result of a large number of requests for information as to the best use of lighting as a precautionary measure against damage to industrial plants.

Langelier Mfg. Co., Providence, R. I. Catalogue of high-speed belt-driven ball-bearing drilling machines having a capacity from 0 to 11/32 inch. These machines are made with single spindles or in gangs with two or more heads mounted on one pedestal. They can be supplied with motor drive if desired.

New Departure Mfg. Co., Bristol, Conn., has begun the publication of a weekly house organ called "New Departure News," for circulation exclusively among its employes. It is devoted to social matters, sports, timely health hints, personal matters and other news of interest to the employes of a large organization.

New Departure Mfg. Co., Bristol, Conn. Sheets Nos. 91 FE to 94 FE, inclusive, for loose-leaf binder, illustrating the use of ball bearings in bevel drive gearing for vertical shaft of deep well pump, polishing or buffing jack equipped with ball bearings, ball bearing wheels for cableway car, and ball bearings for double winding drum.

National Tube Co., Frick Bldg., Pittsburg, Pa., has issued a wall hanger calendar entitled "National Preparedness," on which appears a poem by Berton Braley having for its theme the part played by pipe in modern civilization. The poem is illuminated with colored views showing some of the many uses to which pipe is applied.

Peter A. Frasse & Co., 417-421 Canal St., New York City. April, 1917, stock list, giving sizes in stock ready for immediate shipment of Frasse electric tool steel, polished drill rods, electric and open-hearth alloy steels, chrome-nickel steels, cold-finished screw steels, cold-drawn flats, coppered Bessemer rods, cold-rolled strip steel, and odd lots of high-speed steel.

Advance Tool Co., Canal and Jackson Sts., Cincinnati, Ohio. Catalogue of small tools, comprising solid counterbores, Woodruff keyseat cutters, side milling cutters, slotting end-mills, end-mills, milling cutters, adjustable hollow mills, plain hollow mills, collet chucks, limit gages, lathe mandrels, roller plug mandrels, hand milling machines, chucking reamers, shell reamers, etc.

Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass. Loose-leaf catalogue illustrating and describing Baush universal joint, Bocorselski universal joint, portable multi-drill heads, Baush patent spindle arm for multiple-spindle drilling machines, high-speed multiple-spindle drilling machines of the hand lever type, and high-speed multiple-spindle drilling machines of the screw type.

Sloan & Chace Mfg. Co., Ltd., Newark, N. J. Catalogue of precision machinery and special tools, showing views of the Sloan & Chace bench lathe equipped with compound slide-rest, milling attachment and screw cutting attachment. The catalogue contains a detailed description of the various attachments and parts of the lathe, and illustrates also bench milling machines, automatic pinion cutters, automatic gear-cutters and drilling and tapping machines.

Kearney & Trecker Co., Milwaukee, Wis. Catalogue 20, illustrating Milwaukee milling machines of the horizontal and vertical types. The various features of the machine are described in detail, such as the column, knee, table and saddle, system of automatic flooded lubrication, constant speed drive, speed and feed mechanism, etc. Specifications are given for the various sizes of Milwaukee milling machines, as well as for the milling cutters that are used with them.

New York Revolving Portable Elevator Co., Jersey City, N. J. Bulletin 50, describing and illustrating the revolvator, a portable elevator or tiering machine with a revolving base, which swings around on its own center like a turntable. The use of this revolvator enables floor space to be used to advantage in piling; it makes it possible to stack heavy and bulky cases, bales, etc., clear up to the ceiling in store-rooms and warehouses, leaving no waste space and making wide aisles unnecessary.

American Tool Works Co., Cincinnati, Ohio. Circular 392, illustrating the American six-foot triple-purpose radial drilling machine, which represents a departure from the standard radial drilling machines in the design of the head, which is quadruple-geared and affords four distinct speeds; these, in turn, are divided into two separate ranges, one for heavy tapping and boring, the other for high-speed drilling and light tapping. The boring and tapping range, in conjunction with the eight gear-box speeds, comprises sixteen speeds ranging from 15 to 81 R. P. M.

Schuchardt & Schutte, 90 West St., New York City. Catalogue of S & S gage standards, which comprise sets of standard blocks or units for measurement and for comparing the accuracy of other standards. These sets are made in different combinations; for instance, the No. 9 set is adaptable for combinations of 0.0001 inch, and the No. 8 for combinations in steps of 0.001 inch. The catalogue gives the number of blocks and the units of measurement for the various sets, and shows holders and measuring jaws for S & S gage standards. It also describes briefly the S & S precision measuring screw-testing microscope.

Kasenit Co., 11 Water St., New York City. Booklet treating of up-to-date methods of casehardening, and giving particulars of "Kasenit" casehardening compounds. The aim of the book is to give useful general information which will enable casehardeners to find out details best suited to their own steel and class of work. The book gives information on carbonizing, carbonizing powder, the re-use of spent "Kasenit," heat-treatment, the hardening shop, casehardening furnaces, heat controlling appliances, quenching, distortion or warping, boxes and how to pack them, tongs and other appliances, cleaning work, open-hearth hardening, and tests of hardness and toughness. "Kasenit" is made in three standard grades, Nos. 1 and 2 being intended for surface and open-hearth hardening and No. 4 for casehardening in closed boxes.

TRADE NOTES

Gibb Instrument Co. has moved from Pittsburg, Pa., to 5716 Euclid Ave., Cleveland, Ohio.

B. L. Mallory Machine Co., 131st St., Cleveland, Ohio, has changed its name to Geometric Stamping Co.

Ternstedt Mfg. Co., Detroit, Mich., maker of automobile accessories, window regulators, etc., announces the opening of its new factory in Detroit.

Walcott Lathe Co., Jackson, Mich., has increased its capital stock from $100,000 to $700,000, and is now in an entirely new factory, equipped with new machinery, and is building approximately 175 to 200 lathes per month.

Worcester Stamped Metal Co., successor to W & S Mfg. Co., Worcester, Mass., has completed an addition to its plant which increases its manufacturing capacity about 100 per cent. The company specializes in stamped metal parts.

Modern Machine Tool Co., Jackson, Mich., manufacturer of the "Modern" cutting-off machine, will erect an addition to its plant that will triple the present floor space. This increase has been made necessary by the rapidly growing demand for its product.

J. N. Lapointe Co., New London, Conn., dedicated its new plant on Pequot Ave., April 14. A public parade of employes and citizens marched through the city, following which there was the raising of the flag and the fourth annual banquet at the Crocker House.

Reynolds Pattern & Machine Co., Moline, Ill., will move its plant to Massillon, Ohio, about August 1, where it will be known as the Reynolds Machine Mfg. Co. The notice in the April number stated that the change of location had already been made, which is incorrect.

Pangborn Corporation, Hagerstown, Md., has purchased and taken over the sandblast business conducted by Elmer E. Perkins and George A. Cooley, Monadnock Block, Chicago. Mr. Cooley has joined the Pangborn Corporation and Mr. Perkins will continue his business in condensing driers and dry kilns.

Maino Machine Tool Co., Jackson, Mich., manufacturer of shapers, has broken ground for a new shop, 60 by 100 feet. The building will be of steel and brick construction, with saw-tooth roof. It is expected that the added facilities will enable the company to meet adequately the heavy demand for its shapers.

Stahl Gear & Machine Co., 1930 E. 40th St., Cleveland, Ohio, has been started by George Stahl, formerly of the Horsburgh & Scott Co., to manufacture gears. The new concern will cut spur gears up to 60 inches diameter, 2 diametral pitch; bevel gears up to 24 inches diameter, 1½ diametral pitch; spiral gears and other gearing products.

Vanadium-Alloys Steel Co., First Ave. and Ross St., Pittsburg, Pa., announces that arrangements have been made whereby the following firms will represent the company in the sale of high-speed steel, also alloy and carbon tool steels: E. T. Ward's Sons, Boston, Mass.; George Nash Co., New York City; Field & Co., Inc., Philadelphia, Pa.; and George Nash Co., Chicago, Ill.

Eccles & Smith Co., 69-71 First St., San Francisco, Cal., announces that Chris. Eccles was recently elected president and manager and Charles F. Bulotti secretary. The company has stores in San Francisco and Los Angeles, Cal., and Portland, Ore., in which is carried a stock of railway supplies, machine tools, small tools, pneumatic and electric tools, air compressors and iron and steel products.

Poole Engineering & Machine Co., Woodberry, Baltimore, Md., has acquired the exclusive manufacturing and selling rights of the "Turbo-gear," formerly manufactured by the Turbo-Gear Co., Inc., of Baltimore. The Turbo-gear is a highly developed speed reduction device for use with high-speed electric motors, steam turbines, other prime movers, etc. A descriptive catalogue is ready for distribution.

Welding Patents Investigating Committee, Room 700, Renkert Bldg., Canton, Ohio, has issued a list of 224 contributors to the investigation now being made by the Welding Patents Investigating Committee into the spot-welding patents. A meeting of manufacturers using spot-welding machines representing a capital of $100,000,000 convened at Canton in February for the purpose of securing a thorough investigation of these patents.

Union Chain & Mfg. Co., Seville, Ohio, manufacturer of steel chain belting, rivetless driving chains, sprocket wheels, buckets, elevating and conveying machinery, etc., has increased its capitalization from $40,000 to $60,000. The company's New York office has been removed to 30 Church St., and remains in charge of J. R. Shays, Jr. Oliver J. Abell, formerly Western editor of the "Iron Age," is in charge of the Chicago office at 565 Washington Blvd.

Acme-Greaves Machine Tool Co., Cincinnati, Ohio, was incorporated under the laws of the state of Ohio, April 4. The new company is a merger of the Acme Machine Tool Co. and the Greaves-Klusman Tool Co., both of Cincinnati. The Acme Machine Tool Co. manufactures turret lathes and the Greaves-Klusman Tool Co. builds a line of engine lathes. The incorporators are C. H. M. Atkins, B. B. Quillen, George Langen, A. J. Jones and William A. Greaves. The new company is incorporated with $1,000,000 capital.

Canedy-Otto Mfg. Co., Chicago Heights, Ill., manufacturer of post radial drilling machines, upright drilling machines, etc., has just completed a large addition to its plant, which will nearly double the capacity. The company has also installed another 25-ton cupola in its foundry, and it will soon place upon the market a line of 14-, 16- and 18-inch medium-priced engine lathes, and a base and column radial drilling machine with 2½- and 3½-foot arms, which will eliminate a number of the expensive features of the higher-priced drilling machines.

H. T. Dempster, 7 E. 42d St., New York City, calls the attention of American manufacturers to the possibilities of developing direct trade connections in Italy. Mr. Dempster resided twenty-five years in Italy, and has acquired a comprehensive knowledge of the economic conditions existing therein. He has developed a plan making it possible for American producers to merchandise their products directly through their own representatives, who, under trade expert supervision, should be able to secure full advantages through local distributors.

Russo-American Merchants & Manufacturers Exchange, Inc., 120 Broadway, New York City, has been established to improve conditions as regards American supply and the Russian demand for American-made products. Russia is regarded as a practically inexhaustible market for American industrial products, and many are raising the question as to the best means of bringing together the consumer and American manufacturer. The Exchange will publish a comprehensive directory of American industries, of which about 40,000 copies will be distributed throughout Russia.

Eastern Brass & Ingot Corporation, Waterbury, Conn., is an organization that has recently moved to Waterbury from Chicago and established a plant for the reclamation of brass filings and turnings. The process employed was developed by O. C. Duryea, and consists of pressing the brass turnings, which have been carefully cleaned of all foreign material, including iron and steel chips, into briquettes, using a press capable of exerting a pressure of about 500 tons per square inch. The resulting briquettes are melted with very little loss from oxidation. The new plant has a capacity of several hundred tons a day.

Alvord Reamer & Tool Co., Millersburg, Pa., has purchased all the property of the Alvord Reamer Co. and the Millersburg Fifth Wheel Co., both of Millersburg, and will continue the long established business heretofore conducted by these companies. The officers of the Alvord Reamer & Tool Co. are F. T. McGuire, president; G. R. Kurrie, vice-president; J. Boyd Coates, secretary; and John Clymer Boltz, treasurer. The company has modern equipment for the manufacture of reamers, milling cutters and special metal-cutting tools of every kind. The capacity of the tool plant and forging department has lately been materially increased in order to meet the demands for the products. Sales offices are maintained in Philadelphia, New York City, Chicago, Minneapolis, San Francisco and Baltimore.

Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio, has completed plans for rebuilding the portion of the plant recently destroyed by fire. The plans include the erection of two additional buildings, which will give better manufacturing facilities for the company's rapidly expanding business. The plans provide for the erection of four complete new buildings, consisting of a machine shop, a three-story stock-room, a new power plant and a structural and forge shop. The machine shop and stock-room are replacements on a much larger scale of the portion burned. The machine shop will be 200 feet long and 100 feet wide, of fire-proof construction, steel, concrete and brick being used throughout, including steel window frames and sashes. The floor space is 100 per cent more than that of the building replaced. An electric traveling crane of 20 tons capacity will serve the center bay, and two smaller electric cranes of 3 tons capacity each will be installed in the side bays. The stock-room building will be 50 by 60 feet, the power plant, 42 by 60 feet, and the steel fabricating shop, 50 by 60 feet. It is planned to have the new buildings in full operation July 1.